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ASPECTS OF PROTEIN NUTRITION IN ANIMALS

By E. J. UNDERWOOD and R. J. MOIR

The rapid and spectacular developments of the last half century in vitamin and mineral nutrition have tended to obscure the substantial advances made in our understanding of protein nutrition. In 1816 Magendie first showed that the nitrogen present in the body had its origin in nitrogen compounds in the food and, a few years later, that proteins were the nitrogen compounds essentially concerned. Advances made since that time enable a fairly clear picture to be painted of protein nutrition in simple-stomached animals, although parts of the picture still remained blurred. With the ruminant, on the other hand, in spite of rapid progress during the last decade, it has become abundantly clear that the position is very much more complex. Only a shadowy outline can yet be drawn.

This complexity is introduced largely by the manifold activities of the vast numbers of micro-organisms which normally inhabit the rumen. An idea of the numbers involved can be gained from the fact that their concentration in the rumen fluid is often as high as 50 to 60 millions per cubic millimetre. This means that an ordinary sheep with a rumen fluid volume of 6 to 8 litres would be carrying a total ruminal microbial population of no less than about 30 to 50×10^7 millions.

These micro-organisms enable the ruminant to make efficient use of fibrous materials which would otherwise be lost to man; to synthesise many of the vitamins, thus rendering the host animal

independent of dietary sources of these compounds; and to utilise a number of simple nitrogenous substances, such as urea, which neither man nor the monogastric animal can use as a source of nitrogen to anywhere near the same extent. In addition, it is now known that they can profoundly influence the nutritive value of ordinary food proteins. Before discussing present ideas on this latter aspect of ruminant nutrition it is worth while outlining the position in the monogastric mammal, especially as all our basic knowledge of protein utilisation has come from studies with such animals.

The Protein Value of Feeds

Under conditions of adequate energy intake and adequate supplies of minerals and vitamins the value of any palatable, non-toxic feed as a source of nitrogen to monogastric animals is very largely dependent upon the following three factors:—

- (i) the protein content of the feed
- (ii) the digestibility of this protein and
- (iii) the "quality" of the digestible protein, i.e., the amounts and proportions of the "essential" amino-acids which it contains.

Direct determination of the various proteins present in feeds is difficult and tedious, but as nitrogen occurs in differ-

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ent proteins in fairly constant proportion (16 per cent. on the average) it is usual to determine the total nitrogen and multiply by 6.25, i.e., $\frac{100}{16}$. For most feeds this involves little error in respect to the proteins themselves, although more accurate conversion factors are now used for the cereal grains and their mill products. This procedure, however, gives a measure of the "crude" protein content because it includes a range of non-protein nitrogenous substances. In herbage these non-protein nitrogenous substances rarely exceed 10 to 20 per cent. of the total nitrogen present and consist mainly of amides, amino-acids and peptides, with usually small amounts of a host of other nitrogen-containing compounds such as nucleic acids, purines, pyrimidines and nitrates.

For many years considerable effort was devoted to measuring the "true" protein content of feeds in the belief that the non-protein-nitrogen was of little nutritional value. A distinction between "true" and "crude" protein has now lost most of its significance, even for non-ruminants. This has been brought about by an improvement in knowledge of the nature of the non-protein substances and an appreciation of the fact that within the animal the feed proteins are soon converted into compounds similar to many of those present in the non-protein-nitrogen fraction. Nevertheless, it is still common British practice to allot to non-protein-nitrogen only half the value of protein nitrogen by the use of the term "protein equivalent". The protein equivalent of a feed is half the sum of the digestible crude and digestible true protein. There may be some justification for this convention in pig and poultry nutrition but with ruminants, as will be seen, there is none at all with ordinary feeds.

Protein Digestibility

Protein digestion in the monogastric animal is essentially a process of hydrolytic cleavage, through various stages to amino-acids. This digestion is carried

out by the proteolytic enzymes of the gastric juice, the intestinal secretions and particularly the pancreatic fluid. Since proteins can only enter the blood stream and begin to take part in the various anabolic processes of tissue building and repair as amino-acids, it is clear that the digestibility of any feed protein will depend upon the extent to which this hydrolytic cleavage takes place.

Different sources of protein are known to vary considerably in digestibility but very little is known of the physiological factors which determine the completeness of protein digestibility, or indeed of the digestibility of any of the food nutrients. This digestibility may, however, be considerably affected by factors within the food itself, particularly those concerned with the accessibility of the protein to the digestive enzymes. Most of the protein of herbage, for instance, is in the chloroplasts of the cell surrounded by cell walls consisting of cellulose and various cellulosic substances, such as ligno-cellulose, which are not readily broken down by the non-ruminant. In this way the accessibility of the enclosed protein to proteolysis can be reduced. This is believed to be the reason for the declining digestibility of protein with rising content of crude fibre in most feeds and the fairly marked fall as lignification of this fibre takes place. It provides some explanation also of the relation of fineness of grinding to digestibility in animals such as pigs which not only do not digest fibre to any extent but also do not masticate thoroughly.

Digestion trials as ordinarily carried out do not measure the true digestibility of protein but merely its "apparent" digestibility. An appreciation of the difference is important to an understanding of protein utilisation but has little practical significance in nutrition. Faecal nitrogen consists of two fractions, the undigested or unabsorbed food nitrogen and the so-called "metabolic faecal nitrogen". This latter fraction originates within the body of the animal and con-

sists of the unabsorbed nitrogenous constituents of the digestive juices, of cellular material and of mucus derived from the gastric and intestinal mucosa. The amount of the first fraction is obviously determined by the "true" digestibility of the food protein but the metabolic fraction is independent of this factor. Its amount, in fact, is determined by the total dry matter consumption of the animal and the fibre content of this dry matter. In omnivora ranging in size from the mouse to man, on the low fibre diets usual with these species, the metabolic faecal nitrogen has been shown to closely approximate 0.2 g. nitrogen per 100 g. of dry matter consumed. Its replacement from the food is essential to the maintenance of the nitrogenous integrity of the body and is therefore a regular item in the protein requirement of the animal. For this reason coefficients of apparent digestibility, which include this item, give a more useful picture of the real nutritive value of different sources of protein. Nevertheless, for the assessment of protein quality it is necessary to determine the "true" digestibility of the protein.

Protein Quality

Forty years ago it was shown by Osborne and Mendel that different proteins varied greatly in their capacity to promote growth in rats and that their value for this purpose could often be considerably enhanced by supplements of particular amino-acids. It was quite logically argued that these were "essential" for the animal and "deficient" in the protein in question. These important findings were confirmed and extended and found to apply without substantial modification to other monogastric species, notably the pig, dog and chick. In this way the concept evolved that protein nutrition is essentially amino-acid nutrition and that the quality or "biological value" of any protein for these species is primarily a reflection of its amino-acid makeup. This explanation of protein quality has been placed on an unequivocal

basis by (a) the application of the new techniques of chromatography and microbiological assay to proteins, so that their amino-acid contents can be determined with reasonable accuracy, (b) the development of greatly improved methods of animal experimentation for assessing and comparing the efficiency of utilisation of different proteins and (c) the classical work of Rose and his colleagues at Illinois with pure amino-acids as the sole source of nitrogen in the diet.

The nature and significance of the progress made under (a) and (b), important and interesting as they are, must regretfully be dismissed from a brief review such as this but the outstanding work of Rose merits further consideration. Rose established that, for growth in the rat, the normal 20 to 22 amino-acids present in feed proteins could be divided into two groups, an essential and non-essential group.

An essential amino-acid is defined by Rose as "one which cannot be synthesised by the animal organism out of materials ordinarily available at a speed commensurate with the demands for normal growth". Accepting this definition the essential amino-acids, for the rat, are 10 in number, namely, arginine, histidine, lysine, leucine, isoleucine, phenylalanine, valine, threonine, tryptophane and methionine. These amino-acids are needed mainly for the synthesis of the protein molecules entering into the structure of protoplasm. For this, the tissues require the simultaneous presence of all the amino-acids which the body cannot manufacture at an adequate rate, for itself, from dietary constituents. The absence from the diet of any one essential amino-acid will block the synthetic processes and a deficiency of any one, relative to its requirement, will lower the efficiency of utilisation or biological value of dietary protein. Thus gelatin, which is entirely lacking in tryptophane, will not support any growth in the rat when it is the sole source of amino-acids and has therefore a biological value for

growth of zero. Most feed proteins, however, have not an absolute but merely a relative deficiency of one or more essential amino-acids. Thus the legume seed proteins are generally deficient in methionine which is regarded as the "limiting" amino-acid in these materials, although recent work by Holmes in the writers' laboratory also implicates isoleucine which may be equally deficient in a number of cases. Similarly, with whole wheat protein the limiting amino-acid is lysine. Fortunately the leaf proteins appear to vary very little with season or species and possess a relatively good balance of essential amino-acids, although, as with many proteins, the methionine content is slightly low.

Whole egg protein is the best food protein so far studied; in fact, its biological value for growth in the rat is so close to 100 that it is regarded as possessing nearly perfect proportions of the essential amino-acids. It is true that recent evidence suggests that lysine is very mildly deficient for maximum growth, and that the proportions present in egg protein do not agree as closely as might be expected with the relative requirements of the essential amino-acids as determined by the methods of Rose and others. Nevertheless, the use of whole egg protein as an ideal reference protein with which other dietary proteins may be compared is an extremely helpful procedure. This method was suggested by Mitchell and Block in 1946, who compared the percentage of each essential amino-acid in the test protein, determined by appropriate methods, with the percentage present in egg protein. The amino-acid present in the least proportion, *compared with the amount of the same amino-acid in egg protein*, is regarded as the "limiting" amino-acid, i.e., the most deficient, nutritionally speaking. This, of course, may not be the one present in the smallest absolute amount. The percentage deficit of each of the essential amino-acids can be calculated

and the "total per cent. deficit" also evaluated.

The total per cent. deficit has its uses in ranking ordinary proteins roughly in the order of their biological value but can be very misleading in particular cases. The per cent. deficit of the limiting essential amino-acid, on the other hand, correlates quite well with biological value and gives, in addition, information on the principal factor determining that value. It should be pointed out, however, that not infrequently proteins are deficient in more than one amino-acid to roughly the same degree. Thus Holmes has recently shown subterranean clover seed protein to be severely and almost equally deficient in methionine, isoleucine and threonine.

It is exceedingly important to appreciate that the foregoing remarks on protein quality apply only to the requirements for growth in the rat. An essential amino-acid, as defined by Rose, may not be equally essential for other physiological functions such as reproduction, lactation or for detoxication or maintenance in adult animals or indeed for growth in other species. A very great deal remains to be learned on these vital matters but it is already clear that, quite apart from the ruminant to which later reference will be made, significant qualitative and quantitative differences between species exist. Thus adult man does not need either histidine or arginine preformed in the diet for the maintenance of nitrogen balance, and the adult rat and dog do not require arginine. In contrast to this, the growing chick is more demanding in its amino-acid requirements than either the rat or dog, because in addition to the 10 "essential" amino-acids of Rose it needs glycine and glutamic acid and under certain conditions benefits from dietary additions of proline, cystine and tyrosine. Many interesting speculations on the biochemical reasons for these differences in terms of relative rates of growth of different

species and of the relative magnitude of keratin synthesis in hair, wool and feathers could be made, but it would take us far beyond the scope of this review.

Before considering certain special aspects of ruminant nutrition, however, an important recent development in amino-acid nutrition concerning the non-essential amino-acids must be mentioned. This is the demonstration that these amino-acids can be synthesised by the monogastric animal from simple sources of nitrogen in the diet. When the 10 essential amino-acids were supplied to growing rats at minimum requirement levels, the addition of nitrogen to the diet as ammonium citrate, ammonium acetate, urea, glycine and glutamic acid permitted much improvement in growth and nitrogen retention. Moreover, it has been shown that these simple forms of nitrogen are used more efficiently for general synthetic purposes by the rat than the essential amino-acids themselves.

These findings open up a number of interesting problems regarding the biochemical reactions involved in the synthesis of the wide range of nitrogen compounds present in the body. Some of these problems are already being tackled by the use of compounds labelled with the N^{15} isotope. They also raise the question of the possible role of the intestinal micro-organisms of monogastric species in such synthetic processes.

Protein Utilisation in the Ruminant

The utilisation of food nutrients by the ruminant differs in a number of important respects from the monogastric animal but particularly in the much longer period of digestion. During this longer period opportunity is provided for efficient maceration of the food particles and for effective fermentative breakdown by the micro-organisms of the rumen.

Food protein in the rumen can enter the metabolic processes of the body by a number of alternative pathways. Part of it passes on unchanged to the abo-

masum or true stomach where hydrolytic cleavage begins and thence to the small intestine where hydrolysis continues in much the same way and with the help of the same digestive enzymes as in the monogastric animal. Portion of this protein is absorbed into the bloodstream as amino-acids in the normal way and portion escapes the intestinal proteases and is excreted as part of the undigested nitrogen of the faeces. Even less is known of the physiological factors determining the extent of this type of digestion in the ruminant than in other species.

A second pathway is as follows. Food protein is broken down, largely to ammonia, by the micro-organisms of the rumen, is assimilated by them and built into microbial protein which passes on to the abomasum and thence to the small intestine where it is exposed to the same proteolytic enzymes as the unchanged food protein which has reached this site. It therefore becomes a source of amino-acids to the animal. Finally, part of the food protein converted to ammonia in the rumen is absorbed by the animal directly from the rumen and may be largely excreted as urea. All of this ammonia and urea, however, may not be lost, because part of it returns to the rumen in the saliva where it becomes once more available to the ruminal micro-organisms for synthesis into microbial protein. The synthesis of protein in this way is of extreme interest because it amounts to a recovery of waste nitrogenous products ordinarily regarded as completely unavailable to the body. This may exert a significant effect upon the efficiency of protein digestion under conditions of low nitrogen intake.

Protein Quality in the Ruminant

In view of the close similarity in the amino-acid composition of body tissues in all species of animals studied it is reasonable to assume that the requirements of the ruminant for *absorbed* amino-acids for body growth and repair are similar

to those of other species. It is obvious, therefore, that the "quality" of any feed protein or nitrogen source to the ruminant will depend upon the degree to which it follows one or other of the alternative pathways described above and not, as in the non-ruminant, merely upon the proportions of the essential amino-acids which it contains. Thus a protein rich in essential amino-acids which, for some reason, is rapidly de-aminated with absorption of ammonia from the rumen and loss of this ammonia as urea, could clearly have its "quality" greatly reduced. Conversely, a very poor protein, or even a simple substance, such as urea, which contains no amino-acids at all, fed under conditions which favour bacterial proliferation in the rumen, could be greatly enriched in essential amino-acids by the synthetic powers of these bacteria in building their own body protein.

Fortunately, a glimmering of the physiological factors which determine which pathway will predominate with any particular nitrogen source is beginning to appear. For instance, McDonald, at Cambridge, has shown that zein, the chief protein of maize, is converted very slowly indeed to ammonia, and Synge, at Aberdeen, that casein is very rapidly de-aminated compared with herring meal protein. These findings suggest that the solubility of the protein is one important factor. Further, there is evidence that a low proportion of fermentable carbohydrate in the diet favours ammonia formation.

For efficient conversion of urea to rumen bacterial protein there is abundant evidence that conditions in the rumen must be favourable for rapid bacterial growth. The primary requirement for such bacterial growth is an adequate supply of readily available carbohydrates such as starch, because the more refractory carbohydrates, such as cellulose, are attacked comparatively slowly in the rumen and their main disintegration products, the lower fatty acids, cannot be

used by the rumen bacteria as a source of energy. Consequently, unless there is an adequate supply of readily available carbohydrate there is insufficient energy available to the rumen bacteria to enable them to utilize the ammonia from urea prior to its absorption from the rumen. It is for this reason that urea added to a predominantly roughage diet is so poorly utilised by sheep and cows. Only when the diet contains sufficient suitable carbohydrate to permit rapid bacterial proliferation can these animals make effective use of urea or ammonium salts. This has been demonstrated by many workers in this country and elsewhere and is of the greatest practical significance. It must be borne in mind further that the micro-organisms of the rumen exist under strictly anaerobic conditions, which limits the energy available to them to a fraction of that yielded from the same source under aerobic conditions.

An ample supply of readily fermentable carbohydrate is by no means the only factor influencing the utilisation of compounds like urea. Experiments by the authors and by Loosli and co-workers at Cornell have demonstrated unequivocally that additions of methionine, and to a lesser extent inorganic sulphate, to a urea diet containing adequate starch, can significantly improve nitrogen retention by sheep. These results cannot be fully interpreted as yet but are clearly related to the mineral, particularly sulphate, content of the basal rations used. They are of considerable interest and importance and demand the closest study, particularly in view of the special importance of the sulphur-containing amino-acids in relation to wool growth. The very considerable volume of literature on this subject and the possible significance of the above findings in this connection require a separate review and cannot be pursued here.

One other aspect of this problem of the conversion of dietary nitrogen to rumen bacterial protein and its relation to pro-

tein quality in the ruminant must be mentioned. In the preceding paragraphs emphasis has been placed upon the importance of nutritive conditions in the rumen, particularly the supply of the right kinds of carbohydrate, in the utilisation of simple nitrogenous substances such as urea. The degree of conversion of ordinary food proteins to rumen bacterial protein is similarly influenced by the nature and amounts of carbohydrates in the diet. It is also influenced by the protein content of the diet or, more accurately, by the protein intake by the animal and by the nature of the protein fed. Johnson, at Illinois, has presented evidence indicating that up to a level of 10 to 12 per cent. crude protein in the diet, a considerable proportion of the protein ultimately utilised by the ruminant is microbial protein, regardless of the source of the dietary nitrogen. If this were true, all food nitrogen up to this level of intake, should exhibit a biological value characteristic of the nitrogen of the mixed micro-organisms reaching the abomasum and duodenum and should therefore vary very little. Actually, significant differences in the biological values in ruminants of different nitrogen sources have been found by several groups of workers. Thus Williams and Moir, in this laboratory, found the biological values for the growth of lambs of a range of nitrogen sources, fed in the same basal ration at the same level of intake, (about 10 per cent. crude protein equivalent), to vary from 69 to 87. These workers obtained later evidence which suggested that the proportion of protein in rations of casein and oaten hay converted to rumen bacterial protein diminished sharply as the intake of casein increased.

It is apparent therefore that the degree of conversion of dietary nitrogen to bacterial protein is highly variable and subject to many influencing factors—factors which must affect the biological value of the dietary nitrogen. When these are considered in conjunction with all the other factors which affect nitrogen

utilisation in the ruminant, mentioned in earlier sections, the use of the term biological value in ruminant nutrition, at least in the sense in which it is used in the nitrogen nutrition of non-ruminants, becomes a highly dubious procedure.

The Nutritive Value of Rumen Bacterial Protein

The fact that a variable but sometimes high proportion of the protein ultimately utilised by the ruminant as a source of amino-acids is rumen bacterial protein has naturally led to a number of investigations of the nutritive value of this protein. These have included conventional nitrogen-balance studies with rats to determine digestibility and biological value and, quite recently, amino-acid estimations on the protein of bulk samples of the mixed bacteria of the rumen of sheep. The former studies have established that rumen bacterial protein is rather low in digestibility but relatively high in biological value when fed as the sole source of nitrogen to growing rats. The biological value for rumen bacterial protein, obtained in the authors' laboratory, was 79 and was not significantly different from that of casein fed under the same conditions. The amino-acid composition of this protein is of considerable interest. The general pattern of amino-acid distribution is very similar to that found elsewhere for other bacteria grown under a wide range of conditions. This supports the generally accepted conclusion that the amino-acid composition of the protein of micro-organisms is not greatly influenced by the conditions of growth and suggests strongly that rumen bacterial protein is relatively constant in composition under different conditions in the rumen.

Comparison of the amino-acid composition with that of the almost perfectly utilisable "reference" protein of whole egg reveals the fact that rumen bacterial protein is well supplied with arginine, histidine, valine, tryptophane and cystine, is slightly deficient in leucine, threonine,

and phenyl-alanine and is very deficient in methionine and iso-leucine. In fact, the "limiting" amino-acids, in the Mitchell and Block sense of that term, are almost equally methionine and iso-leucine. On the other hand, if a comparison is made with more common sources of dietary protein, rumen bacterial protein is revealed in a more favourable light. It is, for instance, superior to pea seed protein and markedly superior to subterranean seed protein as a source of essential amino-acids. Confirmation and extension of these very recent findings are badly needed in order that we may know more of the nature and significance of a protein which is the ultimate source of amino-acids of an important, if variable, part of dietary nitrogen in the ruminant. In addition, as mentioned earlier, much further study is necessary of the factors which influence the degree of conversion of food nitrogen to this protein within the rumen. In this way will come a better understanding of nitrogen utilisation in these species.

Up to this point only the bacterial fraction of the rumen population has been considered. In addition, a vast population of ciliates and flagellates exist. Moir for local conditions, Van der Wath in South Africa and Johnson in U.S.A. have recorded protozoal counts as high as 1000 per c.m.m. and the *Selenomonas* species present in the rumen exceed this concentration many fold. When the much greater size of these organisms, compared with bacteria, is considered, it can be calculated that densities of this order represent a bulk of microbial protein within the rumen approaching that present in the bacterial fraction.

Much less is known of the proteins of the non-bacterial fractions of the ruminal micro-organisms and of the factors which influence their formation than is known of rumen bacterial protein and its formation, although there is evidence that the protein of the rumen protozoa is much more digestible and is as high or higher in biological value for the growth of rats than the protein of the rumen bacteria. These protozoa have generally been dismissed as of little importance to the host animal but recent evidence shows that they are capable of independent life and suggests that young ruminants do not thrive in their absence. These facts clearly call for further consideration of this portion of the rumen population in relation to the nitrogen metabolism of ruminants.

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THE EXPORT OF BEEF FROM AUSTRALIA

By J. R. VICKERY

After 14 years of abnormal conditions, the meat export trade appears now to be gradually resuming its pre-war pattern. Supplies of meat available to Australia's chief customer, the United Kingdom, are approaching pre-war levels. It is possible that, in the next 18 months, the rationing of meat in the United Kingdom will cease and that Australian exports will be conducted wholly on a trader to trader basis.

Limited exports of the highly perishable chilled beef have recently been resumed from Australia, New Zealand and South America after a lapse of over 13 years. It is opportune, therefore, to review the technical basis of the normal export trade in beef from this country, and to assess the likely influence of the results of scientific research on the future pattern of this trade.

Forms of Preparation.

Australian exports of first and second grade beef are usually shipped in the form of quarters. Within 60 to 90 minutes of slaughter, the dressed sides of beef are placed in chilling rooms held at temperatures in the range 31-35°F. In the case of beef exported in the frozen condition, the purpose of this chilling operation is to "set" the meat so that the sides of beef may be cut into quarters without risk of slip of the meat over the bone at the cut ribs. After a period of one to three days in the chilling room, the sides are quartered, the briskets and shins being removed from the forequarters (now called "crops") and the hindquarters and crops are removed to freezing rooms maintained at temperatures in the range 0-10°F., with or without forced air circulation. A period of three to five days is usually required for freezing, after which

the quarters are given a protective covering of stockinette and/or hessian bags and removed to a frozen store, usually maintained at 8-10°F., to await shipment.

In the preparation of chilled quarters for export, a rigid system of slaughter-floor and chilling room hygiene must be maintained, together with high rates of cooling and air circulation in the chilling rooms, in order to keep the surface microbial contamination at a low value. After cooling for 48 to 72 hours, the sides are quartered, and the hindquarters and crops stored in holding rooms maintained at approximately the freezing point of beef muscle (30.5°F.), to await shipment; this holding period seldom exceeds five days.

For shipboard transport, the frozen quarters are stacked in general-purpose, refrigerated cargo spaces maintained at 10-14°F. Apart from the exercise of care to prevent superficial thawing during transfer from the meat-works to the ship, the shipboard transport of frozen beef does not require any unusual precautions.

On the other hand, the extreme care which has been exercised in the preparation of chilled beef in the meat-works must be continued on shipboard. The quarters are hung from rails in special gas-tight chambers which are maintained precisely at 29.5°F. and have a concentration of 10 per cent. carbon dioxide maintained in the storage atmosphere in order to reduce the rate of microbial growth during the long voyage of 40 to 55 days. Whereas one ton of frozen beef occupies 85 to 90 cu. ft. of cargo space, chilled beef usually requires 110 to 120 cu. ft. per ton.

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Considerable quantities of frozen boneless beef are exported from Australia. Such beef is usually derived from lower grade carcasses and is intended mainly for the manufacture of small goods and products such as pies. In its preparation, the bones are removed from the quarters after chilling, and the meat divided into various "butchers' cuts" such as topsides, shoulder clods, etc. The cuts are placed on trays in freezing rooms or tunnels, and, after completion of freezing, they are packed in jute bags and stored at 8-10°F. pending shipment. Roasting and stewing cuts for special contracts are packed into cases containing 50 lb. of meat and subsequently frozen.

Considerable quantities of lower grade beef are also exported in the form of canned corned beef, luncheon meat and stew.

Trade Patterns.

In the five years from 1935 to 1939, Australia exported an average of 125,000 tons of beef each year, about 85 to 90 per cent. going to the United Kingdom; about 110,000 tons were exported in the form of quarters and the balance as boneless beef.

Since 1945, exports of quarters and boneless beef have fluctuated considerably from 108,000 tons in 1947-48 to 39,000 tons in 1951-52 but generally there has been a considerable reduction on pre-war exports, due mainly to production not keeping pace with the rapidly increasing Australian population.

The exports of canned beef have been considerably greater in the post-war, than in the pre-war years, reaching the surprising total of 80,000 tons (approx.) in 1952-53. While there is every indication that the trend of increased exports of canned beef will continue, the probable early suspension of rationing in the United Kingdom will reduce demands far below the inflated level of 1952-53.

Since it is likely that the quantities of quarter beef exported from Australia will always greatly exceed the combined

quantities of boneless and canned beef, the discussion will be confined mainly to this form of export.

Up to 1934, all export quarter beef was shipped overseas in the frozen form, mainly from the Queensland ports of Brisbane, Gladstone, Rockhampton, Bowen and Townsville and also from Wyndham in Western Australia. In 1934 the techniques of preparing and transporting chilled beef were introduced, and in the years 1934 to 1939, an increasing proportion of quarter beef was shipped in this form. For instance, in 1938, about 29,000 tons of chilled beef were shipped mainly from Queensland ports, this quantity being about one-third of the total exports of quarter beef.

The outbreak of war in 1939 put an end to this developing trade at a time when the meat-works and the shipping companies were developing standard techniques for its conduct and were becoming skilled in the various difficult measures which had to be adopted to safeguard this perishable product. Since the maximum time that chilled beef can be stored is about 9 weeks, the inevitable delays to war-time shipping made the continuance of chilled beef exports impracticable. After the war, the continuance of meat rationing in the United Kingdom again precluded an early resumption of chilled beef exports, since rationing requires the holding of considerable reserves of frozen meat to tide over periods of widely fluctuating supplies, and chilled beef cannot be held as part of the reserve but must be disposed of within a few days of discharge from the ship.

Since this trade was cut off in its adolescence, it is difficult to say whether the proportion of chilled to total quarter-beef exports would have increased if the war had not intervened. There were signs, however, of a distinct "flattening-out" of the curve of exports of chilled beef by 1939. Several authorities in the trade believed that the proportion of chilled to total exports would never have

risen beyond 40 per cent. The reasons for their belief were as follows:—

1. For the export of chilled beef to be profitable, the trade required young, or comparatively young, beef of first quality, preferably within the weight range of 480-760 lb. per carcase. The proportion of beef meeting these requirements of quality was then, and still is, not large. The quality standards adopted therefore restricted the quantities which could be forwarded in each shipment.
2. The maximum period for which chilled beef can be held in the meat-works pending shipment is about one week. For all ports, except perhaps Brisbane, the frequency of the shipping service was far less than one vessel per week. Therefore, in the intervening period between arrival of ships, only frozen beef could be prepared at the majority of the beef exporting works.

Assuming that meat rationing in the United Kingdom will cease in the near future, it is pertinent to inquire whether the pattern of the exports of our beef, in the next few years will be similar to that prevailing in the years 1934-1939. If the old pattern obtains, then, for the reasons given above, we shall be endeavouring to export about one-third of our quarter beef in the chilled condition. The question then arises as to whether such an endeavour will be worth-while. In the examination of this question, considerable guidance can be obtained from scientific data on the keeping quality and forms of deterioration of beef; there are also some useful economic data to assist in reaching tentative conclusions.

Characteristics of Chilled and Frozen Beef

It has already been mentioned that the maximum storage life of chilled beef is about nine weeks and that it must be consumed within a few days of discharge from the ship. On the other hand, frozen beef has a storage life of at least 12

months at normal storage temperatures in the range 8-10°F. Compared with chilled beef, frozen beef is much less exacting in its requirements at each stage of preparation, cooling, storage and transport. Moreover, frozen beef is not so dependent on the maintenance of strict and frequent schedules by refrigerated cargo ships. The frequency with which ships need to call at the loading ports is governed more by the storage capacity at the meat-works than by the need for frequent "lifting" of stored frozen meat in order to prevent undue deterioration in quality.

It is frequently stated in the meat trade that chilled beef is more palatable than frozen beef. It is difficult to say how far such opinions are due to real deterioration in the eating quality of beef during freezing and frozen storage, and how far they are due to the fact that the better quality beef has usually been segregated for chilling and the lower quality for freezing preservation. The matter is now being studied in co-operative research work conducted in Australia, New Zealand and Great Britain. In these investigations, paired quarters are being compared. While the experiments have not been completed, the results so far do not reveal any consistent differences in the three aspects of palatability (flavour, tenderness and juiciness) in quarters submitted to chilled and frozen storage.

One of the objections to frozen beef on the part of the retail butcher is that it is inconvenient to handle because it requires several days to thaw. The operation of thawing, therefore, requires additional space in the shop or special facilities for more rapid thawing. These objections by the retail butchers could, perhaps, be overcome by the provision of central thawing facilities by the wholesale distributors so that the quarters would be sufficiently soft to be cut up when they reached the retailer; although some attempts have been made in the past to provide such facilities, they do not appear to have been commercially feasible. Nevertheless, the

inconvenience of thawing cannot be regarded as a serious defect, since similar objections could be applied, to a lesser extent, to frozen lamb, mutton and pork; these products are accepted without question by the British retail butcher although, of course, these carcasses take a shorter time to thaw than beef quarters.

The major defect of frozen beef is that it is subject to exudation of a red, viscous fluid from all cut muscle surfaces during thawing. The extent of this exudate, called "drip", is usually insufficient materially to lower the nutritive value of the meat, since the total loss of fluid during normal butchering operations seldom exceeds 2 per cent. of the weight of the meat. The main objection to the presence of drip is the rather unpleasant appearance which it gives to the meat, creating in the mind of the consumer a prejudice against frozen beef. An additional objection to frozen beef is the frequent development of a dark colour of the muscle on all freshly cut surfaces during thawing.

Prevention of "Drip"

Since the most serious objection to frozen beef is the presence of drip during thawing, many investigations have been directed toward its cause and prevention. Early work carried out some 25 to 30 years ago concentrated upon the effects of the rate of freezing and the temperature of storage on the extent of drip. Several investigators, e.g., Cook *et al* (1926), showed that high rates of freezing could reduce drip to negligible amounts. While the effects of the rate of freezing varied considerably between different muscles, in general it was necessary for the slowest cooling part of the meat to be reduced in temperature from 32 to 23°F. in less than 40 minutes (Moran 1932). This high rate of cooling is commercially impracticable in beef quarters and also in most butchers' cuts such as rumps, loins and shoulder clods. Even by the fastest commercial methods, the time of cooling of quarters from 32 to

23°F. cannot be reduced much below eight hours, a rate sufficient to result in substantial drip from most cut muscles. The required high rate of freezing can be achieved commercially only in comparatively thin "consumers cuts" such as steaks.

Studies on the effects of the temperature of storage have shown that the tendency of rapidly frozen beef to drip during thawing steadily increases during frozen storage, the higher the temperature the greater being the tendency. Beef frozen at the critical rate must, therefore, be stored at as low a temperature as possible. In practice, the rate of change is not great at 0° to -5°F. and rapidly frozen beef can be stored for four to six months in this temperature range without appreciable reversion to the slowly-frozen condition. On the other hand, storage at temperatures above 10°F. leads to fairly rapid reversion.

Empey (1933) showed that the extent of drip was dependent on the pH value of the thawed muscle, minimum "drip" being obtained from muscles having pH values of 6.3 or higher. While these results pointed the way to a possible new method of control of drip, further work was not attempted until recently when co-operative investigations on beef preservation were initiated in England, Australia and New Zealand. These new studies were linked with the work of Bate-Smith and his colleagues on the detailed changes occurring in muscle immediately after death. Bate-Smith (1948) showed that the pH of muscle in full rigor (the "ultimate" pH) varies inversely with the glycogen content of the living muscle, which has a pH value of about 7.3. During the onset of rigor mortis the glycogen breaks down irreversibly to lactic acid which of course steadily reduces the pH value. In practice, the ultimate pH is never lower than 5.3, and in beef muscle it is usually in the range 5.4-5.8. As the result of exhausting exercise or the use of certain drugs just prior to death, the ultimate pH can be maintained as high as 7.0.

If, therefore, the pH of beef muscle, post-mortem, can be prevented from falling below 6.3, then it may be possible to minimise drip in beef quarters frozen comparatively slowly. An additional method of controlling drip, which theoretically has possibilities, is to freeze beef quarters immediately post-mortem, before the pH of the muscle has had time to fall below 6.3. However, it is extremely difficult to cool hindquarters rapidly enough so that freezing precedes the onset of rigor mortis, and it is doubtful, therefore, whether this approach will be profitable. Work is still actively proceeding in the three countries to study the means of controlling pH in beef muscle post-mortem and in achieving control of drip through control of other post-mortem changes in muscle. There are many intrinsic difficulties in the techniques and early results are unlikely.

As an interesting "by-product" of the research studies, it has been found that the higher the quality, as measured by the proportion of intra-muscular fat, the lower the drip. This finding lends further support to the axiom of meat preservation that the better the quality the lower is the deterioration caused by any form of preservation.

Other Technical Aspects.

It is likely that any major expansion in Australian beef exports will come from Queensland, Northern Territory and the Kimberley region of Western Australia. Expansion is dependent, however, upon the provision in the inland areas of adequate transport facilities, chiefly railways (Anon. 1953). All the export meat-works are located on the eastern coast of Queensland and at Wyndham. If the new transport facilities are provided, the question of the establishment of export meat-works in the inland areas will certainly arise.

Slaughtering facilities close to the main inland centres of production would undoubtedly restrict the decline in quality of the carcasses which now occurs when

cattle are transported long distances to the coastal meat-works. Nevertheless, there are many other factors, chiefly economic, which must be considered before any conclusion on the feasibility of inland works can be reached.

One factor which may be overlooked is refrigerated transport of the frozen and chilled beef. If the inland meat-works were situated a long distance (more than 700 miles) from the nearest deep-sea port, a period of three to five days would elapse between the loading of the beef at the meat-works and its discharge into the ship's refrigerated cargo spaces. During this time, no part of the load of frozen beef in the refrigerated rail car should rise above 21°F.; beef at temperatures above 21°F. is too soft for stacking in the ship's cargo spaces. The temperature of export chilled beef during rail transport should not exceed 36°F. In Queensland, at the present time, the refrigerated rail cars used for the transport of meat are unable to maintain these desirable temperature conditions in beef during very long journeys and some softening of frozen meat and excess temperatures in export chilled beef would occur within 24 to 36 hours of loading (Hicks, 1952). If inland meat-works were established, it would therefore be necessary to provide improved refrigerated rail cars whose efficiency should be at least equal to that of New South Wales TRC (overhead bunker) cars.

Packaged Frozen Cuts

An alternative method to shipping good quality beef in the form of quarters is to prepare, freeze and pack household cuts such as steaks, roasts, etc. in the meat-works. In other words, the final dissection into cuts normally consumed in the home and restaurant would be made at the place of slaughter and not in butchers' shops in the United Kingdom and elsewhere. Each cut would be individually wrapped.

The methods and equipment by which this form of distribution can be effected

are now freely available and there are no technical obstacles to be overcome. The usual objections to frozen beef should not apply since the cooking of the cuts purchased by the housewife or restaurant would normally be started while the meat was frozen. There would, therefore, be no apparent drip to disfigure the appearance of the meat. Packaging films which minimize the desiccation and loss of bloom during storage are now available.

Nevertheless, the wholesale and retail meat traders have always been strongly opposed to this form of distribution. Moreover, it would require the provision of refrigerated storage and display cabinets in each retail outlet, and these are seldom available in the United Kingdom. For the time being, therefore, it is unlikely that a major part of Australia's surplus beef can be exported in the form of packaged frozen cuts.

Economic Factors

While the arrangements for the purchase of beef exported to the United Kingdom are conducted on a Government to Government basis, the costs of ship-board transport will be met by the British Government. When such exports revert to the trader to trader basis, then the freight costs will have to be paid by the exporter. It is pertinent then to enquire whether the prices likely to be obtained for chilled beef will result in a better return to the exporter to compensate him for the greater trouble and risk involved in its export in this form rather than as frozen beef. The only guide we have in attempting to forecast the future is, of course, the pre-war experience, which will now be examined in an attempt to assess the economic prospects of the trade.

In 1938, the last full year of export of chilled beef, the average prices (sterling) of Australian frozen and chilled beef on the Smithfield (London) Markets were 3.97 and 4.35 pence per lb. respectively (Q.M.I.B. Annual Report 1939). The small difference in favour of chilled beef

(0.38 pence) is 9 per cent. of the frozen price. This comparison of prices is, however, not quite fair, because, at slaughter, the average initial quality of the chilled beef, which was usually specially selected, was higher than the average initial quality of the frozen beef. If it were possible to compare the prices received for chilled and frozen beef of similar initial quality, then the price differential would be less than 9 per cent.

During 1952-53, the average contract price for frozen beef purchased by the British Government was 13.5 pence (stg.) per lb. If the same percentage differential in price between chilled and frozen beef operates in the coming years, and if the prices received on a free market approximate those of the contract, we might expect the average return for chilled beef to be 14.7 pence per lb., or a difference of 1.2 pence per lb.

Will this small difference be sufficient to meet the additional charges that chilled beef will inevitably incur? It is impossible to give a satisfactory answer because it is not known, firstly, what the chilled beef freight rate will be, and; secondly, whether the preference by the British consumer for chilled beef will be the same as it was in the past. Nevertheless, the following considerations should be borne in mind.

1. A higher average price per 100 lb. dressed weight will have to be paid for chiller quality cattle than for those intended for export as frozen beef.
2. In pre-war years, chilled beef was shipped from Australia on a special bill of lading, being regarded, in effect, as experimental cargo. The freight rate was then only 0.25 pence (stg.) per lb. higher than that for frozen beef. In view of the greater space occupied by a ton of chilled than by a ton of frozen beef and the more costly special gas-tight cargo spaces which have to be provided on shipboard, it is likely that in the

future shipowners will require the chilled beef freight rate to be substantially greater than that for frozen beef.

There is no certainty, therefore, that the export of chilled beef on a free market will be more profitable than frozen beef. Nevertheless, even if it is not more profitable, Australia may be obliged to export as much chilled beef as possible in order to maintain its competitive position in British markets and to find an outlet for the whole of its surplus beef.

In the post-war years, there have been no developments in other overseas markets for meat which appear likely materially to alter the proportion of our beef exported to the United Kingdom. Substantial, alternative markets for chilled beef in countries, such as U.S.A., Malaya and British West Indies, seem unlikely to develop.

Conclusions.

Until methods are available for the elimination of drip from beef during thawing, the export of chilled beef must be encouraged despite the fact that there are no strong reasons for believing that it will be much more profitable to export beef in this form rather than in the frozen state. The techniques and equipment necessary for chilled beef export have been clearly defined, but a prolonged period of training of operatives will be necessary before we reach the standards of efficiency attained in 1938-39.

In view of the rather precarious benefits of the chilled beef trade, there are cogent reasons for pursuing an extensive

programme of scientific research work into the nature of the changes occurring in muscle immediately post-mortem and on the cause of, and preventive measures for, drip.

Even if chilled beef exports continue, at least 60 per cent. of the export surplus must be exported as frozen quarters. It would be a wise policy, therefore, to continue research studies aimed at effecting improvements in each stage of the preparation, freezing, storage and transport.

The production of beef cattle will probably remain a major primary industry in a million square miles of tropical Australia. The planned expansion of this industry and the economic welfare of the area may well be vitally affected if a fall in the price of beef follows a lower demand for frozen beef in its present form. Improvements in methods of preservation to be gained through scientific research may, therefore, be an important factor in maintaining the stability of a vast, but often-neglected, region of Australia.

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FARM MANAGEMENT RESEARCH IN AUSTRALIA

By D. B. WILLIAMS

II.

In an earlier paper the underlying theme of extension work as a factor influencing the trend of ideas and the application of the science of farm management was emphasised. Economic aspects of procedures recommended are by no means the only factors involved in establishing effective extension programmes. But attention was concentrated on economic problems in order to place the potential contributions of farm management research in proper perspective. An appraisal of the potential contributions of farm management research to agricultural development in Australia needs also to describe the techniques available for the collection of farm management data, and at the same time to define the usefulness of the science not only in extension work but as a basis for agricultural policies as well. This is the purpose of the present paper.

The Purpose of Farm Management

Many different uses can be made of information which describes the economic aspects of production on farms. Trends in cost and income levels, changes in techniques of production over time, or differences in systems of management in different geographic areas can all be described in economic terms. The usefulness of farm management research is enormously enhanced when it enables general principles to be defined which indicate relationships between systems of farm management and efficiency of production on farms. Such principles may also define how differences in organisation management and managerial capacity of the farmers are related to differences in income earned.

Three main categories of information relating to the economics of production may be defined.

(a) *Description of Trends in Production Technique and in Cost and Income Levels.* In recent years the use of index numbers of prices paid and prices received by farmers has become more widespread as a means of measuring changes in costs and income trends on farms. But there still remains much to be done in maintaining a running record of changes in production methods, and of changes in the relative importance of the different components of costs. Indeed such information is essential if a correct basis for weighting the components of index numbers is to be available. The information is also useful for its own sake. It is desirable, for example, to know the rate at which mechanisation is occurring in different farm operations; the effects of a new variety or a new technique (e.g., myxomatosis, subterranean clover) can be very well measured if the productivity of the land and the costs incurred are measured continuously. These measures of trends need to be established for each major area, and for different types of farming, as well as in terms of specific commodities. The geographical differences between areas are accompanied by differences in the rate at which new

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changes and responses to price trends are made. Analysis of economic data from farms in different regions enables the significance of observed shifts in production to be interpreted in terms of the changes which caused them in each particular area.

Another vital phase of this descriptive and interpretative phase of farm management are studies relating to so-called institutional factors such as land tenure systems, effects of employee or share payment systems, and other features of the social and political framework within which production on farms occurs.

A specialised knowledge can be built up defining the economic facts of this kind, which influence changes in production techniques in a particular environment. The agronomist, plant pathologist, geologist or soil scientist gradually acquires a background of knowledge which enables him almost instinctively to record the presence of nitrogen deficiency, a plant disease, a rock outcrop or a soil type. In a precisely similar way the social scientist develops an eye for his own sphere of the farm operations, noting the patterns of behaviour and the reasons for them. This understanding is founded on research of a different kind, but it is none the less useful and meaningful. It attempts to interpret the many complexities of the economic activities of man operating in a social environment, in which the outcome of future events can never be known with certainty.

Studies of this kind are essential as a sound basis for agricultural policies and particularly as a basis for interpretation of the effect of national policies on agricultural industries. By providing an understanding of changes in progress on farms they also provide a useful background for those engaged on extension work.

(b) *Studies of Efficiency of Production.* This has been one of the central purposes of farm management research because of its close link with extension

work. It involves analysis of relationships between factors involved in management of farms, e.g., area of farm, capital invested, managerial ability of the farmer, so as to facilitate understanding of the importance of different practices. This includes also measurement of the effects on farm earnings of different practices and alternative methods of organisation of the farm.

Many studies have been made which compare the results—in terms of farm income or some other measure of success—between groups of farms which *did* and *did not* adopt a specified production technique, e.g., soil conservation control measures, mechanisation of certain operations, or different marketing systems. This procedure has been the basis for much of the extension work in farm management in the United States. Subject to certain qualifications regarding comparability of the two groups of farms concerned, this technique of analysis has much to recommend it from an extension viewpoint. The main problem which arises is to ensure that the two groups of farms are of comparable size, soil quality, and systems of production. Then when the results of the comparison are used as a basis for recommendations it is also necessary to analyse carefully the characteristics of the farmers themselves and the factors which influence the farmers to adopt the recommended practice, so that resistances which prevented some farmers from adopting the desirable practice may be understood. These may be lack of working capital, unwillingness to run risks involved, ignorance or lack of skill of the farmer, or a tenure system which does not protect the tenant's rights in any improvements made by him.

The tendency to generalise and to avoid considerations of how each farmer will make best use of a recommendation has been an outstanding weakness of extension services (not only in Australia) and has prevented the successful application of research results made available as

a basis for extension work. But to achieve these ends a reorientation of research is needed, away from descriptive cost data, and away from costs of production per unit of product. The emphasis needs to be transferred to the kinds of costs which influence farmers' day to day and year to year decisions if an understanding of the farmer's attitude and actions is to be secured.

Factors which influence variations in incomes between farms also merit further analysis. In many "cost of production" studies now in progress a range of costs is recorded as between different farmers without analysis of the reasons for the differences between farmers. No more effective extension tool exists than the use of costs and income data which show how the adoption of a practice has increased a farmer's income. The next stage, after securing the acceptance of this new method, is to help the farmer to incorporate it in an individual farm plan (setting out the agricultural and financial programme) and so adapt it to the particular problems of each farmer. The development and execution of this individual farm plan is the end product of extension work.

The purpose of the plan is to study in detail the costs and returns on an individual farm, and to prepare estimates of the results of certain changes in farm operations. This is the budgeting or farm planning technique which is now so popular in the United States and which has been incorporated as an integral part of national programmes of soil conservation, agricultural adjustment and rural credit. The information required for budgets of this kind includes input-output data, showing how production changes as more and more of a given factor is applied; it also includes estimates of costs and of performances which can be expected from available manpower, machinery and land under different conditions. The change contemplated may vary from a change in operations, or in the relative

importance of different farm enterprises, to a wholesale alteration of the whole farming system. Such budgets can only be prepared in a useful way when details of the performance of the enterprises under consideration are known for the soil type, farm size and system of farming on the farm for which the budget is prepared. By taking into account many of the characteristics of the individual farm and farmer for which the budget is being prepared, many of the weaknesses of the "group comparison" method can be avoided; or rather, this method can be developed further to its logical conclusion in its application to individual farms. Strengths and weaknesses of individual farmers and peculiarities of the farm itself can all be allowed for in any individual farm plan.

Nevertheless, in Australia, research has not yet been conducted along lines which provide the data for a full analysis of the problems of individual farmers. The extension worker has not been provided with the research results needed to enable him to appraise the applicability of a particular new technique in accord with:—

- (i) the existing economic circumstances at the time;
- (ii) the problems of the particular locality;
- (iii) the differences existing between individual farms.

Consequently, extension services have been conducted on a hit and miss basis, without any real understanding of the effectiveness of the programme conducted. As soon as individual farm applications are made, the problems of management on the farm influence the acceptance of the advice. The major classes of factors of importance in this respect are:—

- (i) Institutional, e.g., farm size, tenure, credit facilities;
- (ii) Economic, e.g., income levels, expectations of the farmer;
- (iii) Sociological, e.g., the social group in which the farmer lives;

- (iv) Personal, e.g., the managerial ability and preferences of the farmer.

It is in these respects that farm management research can make substantial contributions in Australia in the immediate future.

(c) *Analysis of Decisions Made by Farmers*.—An attempt to fill the gap in knowledge revealed when attempts are made to apply general principles of management to individual farms is now being made by concentrating on the management factor in farm operations. Decision making and the ways in which farmers make judgments of the best way of accomplishing the economic goals they have defined for themselves have recently come into prominence in farm management research overseas. The reason for this trend is that "group comparisons" as described above have been worked to the limit of their capacity. Group comparisons indicate differences in performances, but the reasons for the differences observed between farms must be analysed before steps to correct the observed weaknesses can be made. Most farmers encounter resistances to change in their own farm operations and it is on these resistances that research needs to be concentrated. The fact that farmers who adopt soil conservation earn higher incomes, obtain higher crop yields and are generally *better* farmers can be shown relatively easily. It is much more difficult to define the relative importance of the factors which prevent other farmers from adopting these soil conservation measures. But techniques of research now available, and knowledge of such factors in other countries enable a well-planned scientific approach to the problem to be made in Australia.

These three broad categories cover the field of farm management. Such specific studies as the efficiency of different machines, labour requirements for different operations, farm work simplification, productivity of different soil types,

and the problems of procurement and use of capital, all resolve themselves into one of these three main categories of analysis. Having classified our purposes into these three broad categories, the way is open for a review of the techniques by which farm management research data can be secured.

Farm Records and Account Books

In the United States and in other countries, considerable progress has been made in the establishment of systems of farm records for use by farmers. The records are composed of financial accounts, a diary of events on the farm, and production performances of the different farm enterprises. Great variation exists in the scope and nature of the information recorded, but all have the common feature of a *pro forma* supplied by some supervising agency, by which the farmer is encouraged to keep a continuous record of his farm business. In the past, much of the initiative for this work came from the supervising authority. Nowadays, the usefulness of the records to the farmer in everyday management as well as in compiling income tax returns has added greatly to their popularity among farmers.

For the purpose of this discussion, three distinct types of farm records will be described. The uses and limitations of each type differ slightly. In order to establish the potential contribution of each type of farm record, separate consideration of each method is desirable.

a) *Cost Routes or Detailed Cost Accountancy*.—In this method the supervising agency supplies a field officer who visits a small number of selected farmers to secure full details of all costs and returns, including the distribution of labour and machinery costs among the different farm enterprises. The farmer keeps such records as enable the supervisors to keep detailed accounts on a double entry system, and the recording and analysis is done by the supervisor.

This system was the first method used in the United States to collect data relating to farm management on a continuous and organised basis. It is essentially a means of collecting research data. The method was introduced by W. Hays and A. Boss and his co-workers at Minnesota in 1902 and the first published reports were available in 1906. In later years Illinois and New York also established "cost routes"—so called because the field officer follows a route through the farms, visiting each farm regularly so as to maintain continuous contacts and records. In each of these three States continuous detailed records of costs are now available which provide an historical account of trends in costs and farm practices over the years.

Since the method relies on detailed analysis of each individual farm, the method is costly and comparatively few farms can be included in any one project. At Illinois, for example, there are some 40 farms included, and the project receives the full-time attention of one Professor, one field officer and two clerical assistants. The value of the method depends on the detailed analysis which is possible, especially in recording the use of labour on different farm enterprises, the operating costs and uses of the different farm machines in use on the farms, and the distribution of feed among different classes of livestock. Furthermore, such details are collected continuously as a matter of course, so that a ready source of data is always available describing trends in costs, income, land use and production techniques on these farms. The usefulness of this can only be appreciated by those who have had occasion to depend on other sources of information for teaching purposes, for data needed in administrative decisions, and for data needed in research enquiries. Many times a useful lead to a relationship can be obtained by a study of the information available from these farms. Since details of labour and machinery use are obtained, it is

feasible to distribute overhead costs among different enterprises, and to estimate changes in costs of production per unit of product for each of the enterprises on the farm. No other method enables the relationships between different farm enterprises to be measured so precisely.

In the early days of cost accounting, emphasis was placed on total money costs of production, but in more recent years there has been increasing attention to the physical resources used in production—labour, feed, fuel and machinery usage have been recorded in detail in physical terms, not only as a means of comparing production methods and costs in different areas, as well as changes in efficiency through time, but also as a basis for more realistic farm budgeting.

(b) *Farm Management Service Associations*.—These associations now operate in five States, Illinois (established 1924), Iowa (1932), Kansas (1931), Minnesota (1928) and Wisconsin (1945). The organisation in each case varies, but the essential features are a record book provided by the association, payments by farmers for the service, and a staff of field officers who move from farmer to farmer assisting in keeping the books and providing management advice to the farmer. They differ from the cost route in the fact that they are primarily an extension technique for the participating farmers; the use of labour, feed and machinery in different farm enterprises is not recorded, and the records are less detailed, and a greater responsibility rests on the farmer himself to keep the records. Other important differences arise from the fact that many more farmers are included in these associations than in the cost routes.

The success of the associations depends in large part on the attitude and skill of the fieldman. Some idea of the way in which these officers spend their time in this work may be obtained from an analysis of the work of fieldmen in

Illinois, based on monthly reports of 14 fieldmen in 1949.

	Days of fieldman's time. Average per fieldman	% of time
Office work—home office	61.4	19.9
Office work—university	13.8	4.5
621 farm visits	129.4	42.0
Checking in farm business records	24.0	7.8
Income tax assistance	18.9	6.1
Conducting meetings or tours	10.5	3.4
Attending tours and confer- ences for fieldmen	16.8	5.5
Other meetings, field days . .	16.0	5.2
Time off	17.2	5.6
Total for year	308.0	100.0

The emphasis is on extension work, though research funds in several states are used to analyse results in the account books. Much valuable information on cost trends, income levels and factors affecting efficiency is revealed during this analysis. The fieldman concentrates on individual extension work, but also conducts group tours and meetings.

The co-operating farmers secure assistance in keeping their books, and also have the books analysed for them by the Farm Bureau Farm Management Service. University officers supervise this work. This analysis enables the position of each farmer's business to be compared with that of other farmers with a similar farm organisation. In addition, specialised reports relating to the factors affecting earnings in major enterprises are prepared.

In practice, farmers display very great interest in their performances compared with other farmers; they are always anxious to learn how they stand relative to others and are anxious to learn of the major weaknesses in their farm business.

In the general annual report, average results for specified groups of farms are presented, and each individual farmer's own costs or returns are written into a column provided for the purpose. For example, in 1950, farms were divided into such types as dairy farms, dairy-hog, hog

and grain farms. Within each of these types of farms 2 to 5 size groups were defined, so that a total of 32 different groups of farms was established. This subdivision, and the use of soil productivity as a basis for classifying farms, enables a more realistic use of the group average as a guide to the individual farmer concerned. This fine division of the group of farms with which the particular farmer is compared avoids the criticism once levelled at these comparisons as the "deadly parallels."

Each farmer can compare his own performance with the average of the appropriate group. But differences from the average which are noticed provide guides or leads only, and do not necessarily imply that a different management practice should be adopted. But a low yield per acre, or a high cost of feed, or inefficient use of labour would become apparent when comparisons of this kind are made. Careful interpretation of the results, and on-the-spot discussions with the farmer concerned are essential. In this respect, the field officers became skilled at interpreting the records, and pointing to weaknesses in a particular farmer's methods. The *direction* of the "desirable" change is suggested, and only detailed analysis of the actual farm can define its extent.

(c) *Farm Record Books*.—The two types of farm accounts mentioned above both involve close supervision of the books by the supervising authority. There is another type of farm record book, on a different level of intensity, which is more akin to the record books which have so far been used in Australia. This is the record book, prepared by the supervising authority and issued to farmers for use without assistance in keeping the records. It is used only as an extension technique for the participating farmers and yields no research data.

These records are essentially an extension project, and are supervised in Illinois by the local county agricultural agent, co-operating with the extension

specialist from the College of Agriculture. The great bulk of these books are not summarised at the College of Agriculture.

Assistance in summarising the records is provided at group meetings and by mailed instructions. A number of simple measures such as income, crop yield, value of crops per acre, pigs weaned per litter, returns per \$100 feed fed, etc., may be calculated. Standards of performance prepared in the College of Agriculture from other records, or official statistician's data are used as a guide in the interpretation of the records.

The limitations in these books are obvious. There is no check on the accuracy of the records, nor any interpretation of the farmer's position relatively to other farmers. Some assistance either by a tax consultant, or an accountant, is necessary if full use is to be made of the data recorded.

This discussion of the three major forms of farm records reveals that farm record books may be used for research work or for extension work among the farmers who keep the records. In addition they provide a valuable record of changes in progress on farms. They indicate the results of the year's operations, and provide a sound basis for planning or budgeting and for making changes in the farm business. Not the least important effect is the encouragement given to the farmer to analyse his farm operations in a business-like manner, and to think about his farm costs and returns when considering alternatives.

One important contribution of the farm records has been the development of standards of performance, e.g., yields per acre, output per cow, costs of machinery operation, etc., under different conditions. These are useful guides if not interpreted too rigidly, for they indicate the feasibility of better performances within each of the farm enterprises. These standards have been used in planning and their usefulness extends beyond

the particular farms on which they are based.

The record keeping farms are known to be the higher income farmers and numerous studies have been made to establish the differences between the farmers keeping books and a "random" group of farmers. This sort of analysis merges into research, when the results from the farms are applied to other farms or for other purposes than advice to co-operating farmers. In this work care is needed to define the type of farms to which the results apply in terms not only of farm size, capital supplies and soil productivity but also in terms of the managerial capacity and preference of each individual farmer. The fact that the record farmers are a non-random group does not lessen their value as subjects for analysis of relationships, defined to apply only to specified types of farms.

Record books thus form an important source of research data, though their primary object is extension work.

The record books provide the necessary information for detailed studies of farm enterprises and information recorded as a matter of routine becomes of great significance in a study of efficiency within an enterprise. For example, in the pig enterprise dates of farrowing, number of pigs reared per litter and selling weights are recorded; in the beef cattle enterprise buying and selling dates, and the gain in weight are all recorded and become the basis for useful analyses of these enterprises when comparisons of results from large numbers of farms can be made.

Farm Management Surveys

These comments on the usefulness of account books serve to suggest the particular role of surveys. In areas where no account records are available, the survey must serve to provide any data needed, and this position unfortunately prevails over most of Australia at present. The survey method has the advantage of enabling sampling proceedings to

be adopted, so that a representative sample of *all* farms can be included. It also provides a means of supplementing the data available from censuses and other statistics provided annually by government agencies. Since a complete description of the problems of each individual farm cannot be obtained by the field interview method, the particular usefulness of the survey is in problem-solving research, designed to investigate particular issues not dealt with by routine accounting records. By restricting the survey to farms operating under a defined set of conditions the way in which management problems common to all are overcome can be determined. The survey method also provides an excellent means of securing a picture of the institutional factors which appear to be associated with observed differences in organisation and performance. It depends for its usefulness on the analysis of aggregates, which forms a starting point for more intensive analysis of the relationship of unique features of individual farms to this group pattern which is established.

The lack of data relating to many agricultural industries in Australia has enabled the survey method to be used to make contributions to facts relating to the general economic condition of an industry. The analysis may describe not only the cost structure, but also details as to farm size, management practices, and land use. These surveys of a *fact finding* nature provide essential background data on which administrative plans can be based. For example, in Australia at present there is need for data on such problems as the age of farmers, employee accommodation, losses from major catastrophes such as drought and fire, and the age and effectiveness of farm machinery. Surveys are the obvious means of closing this gap in our present knowledge. The survey method has a clear-cut usefulness suited to the "counting procedures" involved in the detailed analysis of part only of

the operations of large numbers of farms. Such partial analysis may refer, for example, to the use of machinery on farms, to the methods of disease control, to the debt status, or to the price expectations of the farmers included in the survey.

The existence of data relating to the universe being surveyed provides a starting point. Other surveys of a similar kind may also be reviewed, so that both primary statistics and case studies already available can be used to suggest hypotheses and relationships to be tested.

This leads to the importance of formulating hypotheses to be tested *before* the survey begins, in order that these hypotheses relating to the universe being studied can be tested by including in the survey only those farms which are relevant to the problem as defined. This definition of the universe to be surveyed enables the hypothesis to be transposed into corollaries which can be tested in terms of measurable observations which can be expected to be available from these farms. The mere collection of empirical data can be a wasteful and inefficient process unless it is guided by its relevance to some hypothesis which it is designed to test. In this sense, surveys can achieve some of "the elements of the experimental technique", which consists essentially of collecting data under conditions which enable the hypothesis to be investigated, and, after the experiment, to be modified and improved. The term hypothesis is used here in a general sense, to include not only the initial hypothesis established by logic or economic theory, but also the successive refinements to this hypothesis which empirical research makes possible.

At first sight the purely descriptive surveys, as distinct from analytical or problem solving surveys, appear to be exempt from this requirement of using the hypothesis as a guide in the design of the questionnaire. In many cases this is so, but if the usefulness or application of the *descriptive* results is contemplated, an hypothesis will be necessary at some

stage or other. If farm organisations are being described, for example, it is one thing to find that income is higher under organisation A than under organisation B. This is description. But it is quite another thing to indicate why A is higher than B, and to define the particular environment in which this conclusion applies, the difference in managerial skill required to operate under A and B, and the resistances which prevent or hinder farmers from changing from B to A. This is analysis, and an hypothesis designed to answer questions of relationships such as these.

In the United States, as more and more farm management research data becomes available, there has been a change in emphasis in farm management analysis away from analysis of groups of farms, toward analyses of individual farms in relation to the group results observed. This change is in some respects attributable to the emphasis on farm planning and adjustment programmes which has developed since 1933. More attention is being given to the management element itself, and such specific problems as low income farms, small farms, family farms, part-time farms, and beginning farmers have each received attention to determine

their specific problems. While physical performance data and standards of efficiency can provide guides to expected performances under different organisations, they do not explain the resistances within individual farms to the changes which analysis suggests to be desirable. It is on these resistances which the research worker should concentrate attention and which the extension worker seeks to overcome.

If extension workers in Australia are to fulfil this particular destiny, their standing in the farming community needs to be expanding from one founded only on technical advice to one of an economic consultant. This involves a change in attitudes of farmers themselves towards the extension officer, and this in turn might be encouraged by greater participation by farmers themselves in planning and supervising extension work, rather than complete dependence on government instrumentalities as at present. The change also involves an expansion of training of agricultural officers towards economic and social aspects of farming which enable them to analyse farmers' problems in terms which provide realistic and practical solutions to the farmers.

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②

THE RESISTANCE OF WHITE FEDERATION 45 AND DUNDEE 48 WHEAT TO *USTILAGO TRITICI* (LOOSE SMUT OF WHEAT)

By A. T. PUGSLEY

Summary

In crosses with the susceptible variety Ranee, the resistance to *Ustilago tritici* of each of the two varieties White Federation 45 and Dundee 48 has been shown to be conditioned by a single dominant gene.

Introduction

In a previous publication (Pugsley, 1943) it was shown that among the commercially grown wheats of Australia there were several exhibiting a high degree of resistance to *Ustilago tritici*. Although such varieties might well have been used in the breeding of further resistant varieties, relatively little work of this nature has been undertaken. There are several reasons for this, not the least being due to the fact that so little is known of the inheritance of resistance to this disease. If, as the author believes, resistance is best incorporated through the procedure of repetitive back-crossing, then information on this aspect of the disease is most desirable.

The aim of the present study was to secure information on the mode of inheritance of resistance to a single "race" of *U. tritici* in two crosses, White Federation 45 x Ranee and Dundee 48 x Ranee.

Materials and Methods

The two resistant varieties, White Federation 45 and Dundee 48, are each in themselves back-cross derivatives of White Federation 38 and Dundee, possessing stem rust resistance originating from Eureka and Gabo respectively. Preliminary tests have shown them to possess

a resistance to *U. tritici* of the same order as their respective recurrent parents, White Federation 38 and Dundee.

Ranee was selected as the susceptible parent of each cross because it had previously been shown to be a very susceptible variety.

The "race" of *U. tritici* used was the same as that previously described (Pugsley, 1943) and has been maintained during the intervening years on the variety Ranee.

The method of inoculation was as follows:—Selected ears were trimmed to ten spikelets each of two florets and inoculated just prior to anthesis of the most mature florets. In this way the accidental transfer of pollen from plant to plant was avoided. A droplet of a suspension of spores was introduced into each floret by means of a hypodermic syringe.

In most instances duplicate ears from each plant were inoculated. Seed setting of treated ears was usually good, ranging from 70 to 100 per cent.

Inoculated seed was sown in the field where every effort was made to provide conditions which would ensure a high germination of treated seeds. Germination counts indicated no evidence of a dif-

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ferential viability as between seed from susceptible and resistant plants. For each test the sample size was usually of the order of 15-30 plants, the range being 9-49 plants.

It has been convenient to score the proportion of smutted plants in any sample as a percentage. With F_3 families, before a score of 0 per cent. can be taken to indicate homozygous as against heterozygous resistance, it is necessary, of course, not only to have a simple genetical hypothesis, but also to have a certain minimum number of tested plants in each sample for a given level of probability. This minimum number may be simply calculated or deduced from suitable tables (Mather, 1951). In the results which follow, the number of families set down as being homozygous resistant but scored from less than the required minimum number ($P=0.95$) are shown in parenthesis. The inclusion of such results leads to an over-estimation of the number of families in the homozygous resistant class.

Results

White Federation 45 x Ranee

The first tests conducted during 1950-51, although of a preliminary nature, suggested that the resistance of White Federation 45 was conditioned by a single dominant gene. In these experiments inoculated Ranee yielded 90 per cent. smutted plants while both White Federation 45 and the F_1 arising from the inoculation of the cross White Federation 45 x Ranee gave progeny quite free

from smutted plants. Inoculation of the F_1 resulted in 33 per cent. infected plants in the F_2 . Re-inoculation of two partially smutted and of two healthy F_2 plants gave results suggesting that the former two plants were homozygous susceptible and that the latter two were homozygous resistant.

Inoculation of 21 F_2 plants yielded three phenotypically distinct F_3 classes. Six families were free of smut, ten gave infection ratings ranging from 12-50 per cent. and the remaining five gave infection ratings ranging from 84-100 per cent. This segregation agrees closely with a 1:2:1 ratio with a P value of 0.95.

Confirmatory evidence of the above was secured during 1951 and 1952, the results of which are set out in Table I.

From the F_3 data of Table I it is possible to group the 60 families into three phenotypic classes—17 being smut free like the resistant parent, 15 having a smut infection ranging from 51-100 per cent. with a mean of 69 per cent., the remaining 28 families having smut infections within the range 1-40 per cent. with a mean of 19 per cent. This observed segregation is in agreement with an expected 1:2:1 ratio at $P=0.98$ level of probability.

Evidence for the complete dominance of resistance is indicated by the resistant reaction of the F_1 . The mean value of the homozygous susceptible class being 69 per cent., one would expect, on the basis of complete dominance of resistance, a correlation between this value and that

TABLE I

Frequency distribution of loose smut infection of White Federation 45, Ranee and the F_1 , F_2 and F_3 of White Federation 45 x Ranee

Parent or Cross	Distribution of rows having a loose smut infection (%) of										
	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
White Federation 45	3	—	—	—	—	—	—	—	—	—	—
Ranee	—	—	—	—	—	—	—	—	1	1	—
White Federation 45	—	—	—	—	—	—	—	—	—	—	—
x Ranee, F_1	3	—	—	—	—	—	—	—	—	—	—
" " F_2	—	—	2	1	1	—	—	—	—	—	—
" " F_3	17(7)*	6	9	9	4	—	3	7	3	1	1

* See text for explanation.

TABLE II

Frequency distribution of loose smut infection of Dundee 48, Ranee and the F_1 , F_2 and F_3 of Dundee 48 x Ranee

Parent or Cross	Distribution of rows having a loose smut infection (%) of										
	0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Dundee 48	3	—	—	—	—	—	—	—	—	—	—
Ranee	—	—	—	—	—	—	—	—	1	1	—
Dundee 48 x Ranee,											
F_1	3	—	—	—	—	—	—	—	—	—	—
F_2	—	—	5	2	1	—	—	—	—	—	—
F_3	21(9)*	3	9	5	—	1	4	4	3	1	1

* See text for explanation.

obtained for the heterozygous families. Such heterozygous families are expected to contain 25 per cent. homozygous resistant genotypes, 50 per cent. heterozygous resistant genotypes and 25 per cent. homozygous susceptible genotypes. The first two classes would be phenotypically resistant and, with respect to the third class, a penetrance value of 69 per cent. would reduce the expected number of susceptible plants from 25 to 17 per cent. The observed value of 19 per cent. infected plants is in close agreement with this.

Dundee 48 x Ranee

The results from this cross carried out during 1951 and 1952 are set out in Table II.

From the F_3 data of Table II it is possible to group the 52 families into three phenotypic classes—21 being smut free like the resistant parent, 14 having a smut infection ranging from 41-100 per cent. with a mean of 67 per cent., the remaining 17 families having smut infections within the range 1-30 per cent. with a

mean of 17 per cent. This observed segregation fits poorly to a 1:2:1 ratio, the P value approximating 0.01. The unduly large homozygous resistant class is no doubt due to the inclusion of genotypically heterozygous families as described in the previous section. If the heterozygous and homozygous resistant classes are grouped together they total 38, so that with 14 homozygous susceptible families, the ratio of 38:14 is in agreement with a 3:1 ratio at $P=0.8$ level of probability.

The evidence again indicates complete dominance of resistance, and on the basis of a mean value of 67 per cent. for the homozygous susceptible class the observed mean value of the heterozygous class of 17 per cent. agrees closely with an expected value of 18 per cent.

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STUDIES ON PERENNIAL WEEDS: THE SELECTIVE CONTROL OF HOARY CRESS (*CARDARIA DRABA* L. DESV.) IN WHEAT

By R. M. MOORE

Introduction

Hoary cress (*Cardaria draba* L. Desv.) is a particularly serious weed problem in the Wimmera region of Victoria where its control is a matter of considerable economic importance. The distribution of hoary cress in Victoria was described by Pemberton and Prunster (1940).

Studies by Morgan (1931, 1934) with arsenic compounds, chlorates and common salt suggested that arsenic pentoxide and acidified sodium arsenite were most effective in controlling hoary cress. However, unpublished data by Prunster (1940) indicated that the control exerted by these compounds is outweighed by their deleterious effects on soils, crops and vegetation.

The experiment reported here is one of a series initiated in 1946, at Murtoa, Victoria, to determine the effectiveness of chlorinated phenoxyacetic acid compounds for controlling hoary cress.

Experimental

Three dosage levels of 2-methyl, 4-chlorophenoxyacetic acid (MCPA) in the form of the sodium salt, were applied in the spring to a field of hoary cress infested wheat. The wheat at the time of spraying had three or four tillers, four inches in length and the hoary cress was in the early rosette stage of growth.

Hoary cress densities were determined by counts on five fixed 5 x 5 lk. quadrats in each 0.006 acre plot, prior to treatment and thereafter at six monthly intervals for four years.

The wheat was harvested for yields of grain and straw. Analyses of covariance were made on the logarithms of initial hoary cress densities and the two sets of

yield data. There was a negative relationship, irrespective of treatment, between grain yield and the density of hoary cress prior to treatment (Figure 1).

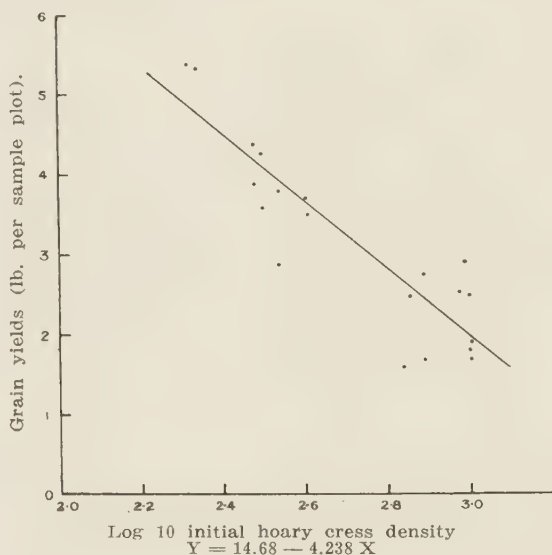


Figure 1. Relationship between wheat grain yield and hoary cress density prior to treatment.

To determine the effect of treatments alone, wheat yields were adjusted by the factor $\bar{Y} - (\bar{X} - X)b$, where

$\bar{Y}$ = mean yield of wheat for a particular treatment.

$\bar{X}$ = general mean logarithm of initial hoary cress density.

X = mean logarithm of initial hoary cress density for a particular treatment.

b = coefficient of regression.

The actual and adjusted wheat yields are shown in Table I.

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After the wheat harvest the experimental area was left out of cultivation for four years and the effects of the original treatments on the hoary cress populations were followed until the spring of 1950. In addition, by using a split-

plot technique, a determination was made of the effects of re-spraying all treated plots with 0.15 per cent. MCPA in the spring of 1947. The reductions in hoary cress densities from the first and second spray applications are shown in Table II.

TABLE I

Yields of wheat treated with sodium, 2-methyl, 4-chlorophenoxyacetate for the control of hoary cress (Cardaria draba). Means of five replications.

Treatments lb./ac. acid equivalent	Initial Number cress plants per sq. lk.	Mean total yield cwt./ac.			Mean total yield of grain bushels*/ac.		
		Actual	Adjusted for initial cress density	Difference of adjusted from control	Actual	Adjusted for initial cress density	Difference of adjusted from control
Control	28.44	11.05	13.35	—	10.40	12.47	—
1 lb. MCPA	22.72	18.08	16.99	3.64	17.00	16.01	3.54
2½ lb. MCPA	23.59	16.54	15.76	2.41	15.27	14.51	2.04
5 lb. MCPA	25.41	15.00	15.70	2.35	14.27	14.90	2.43

*A bushel is taken as 60 lbs.

Minimum differences (adjusted yields) for significance at 5 per cent. level: 2.89 cwt./acre.

2.75 bushels/acre.

TABLE II

Percentage reduction in the density of hoary cress (Cardaria draba) by sodium, 2-methyl, 4-chlorophenoxyacetate applied in the rosette stage of growth. Means of five replications.

Treatments		Percentage reduction compared with untreated at:				
INITIAL August, 1946 lb./acre acid equivalent	SECOND September, 1947 lb./acre acid equivalent	April, 1947	September, 1947	October, 1948	September, 1949	October, 1950
1.0 MCPA	Nil	77.2	58.6	60.3	68.2	42.3
2.5 MCPA	Nil	69.9	43.1	51.3	56.9	28.9
5.0 MCPA	Nil	98.0*	78.5*	53.4	61.3	55.0
1.0 MCPA	1.5 MCPA			73.9	82.3	70.6
2.5 MCPA	1.5 MCPA			83.5	86.1	75.2
5.0 MCPA	1.5 MCPA			89.6	90.5	85.1

Significance: Reductions by initial treatments significant at all dates.

Reductions by second spray significantly greater than initials alone at all dates.

MCPA levels not significant except where marked with an asterisk. P .05.

Discussion

Yield of wheat on land infested with hoary cress was increased significantly by aqueous sprays containing 1 lb. MCPA acid equivalent per acre; higher rates had some toxicity to wheat and reduced part of the gain from lesser competition from hoary cress. This agrees with results obtained on weed free wheat (Moore, 1950).

Spraying with 1 lb. per acre MCPA increased grain yield by 28 per cent. or 3.5 bushels per acre. The existence of competition from hoary cress prior to spraying is suggested by the inverse relationship between wheat yields and initial hoary cress densities (Figure 1).

The greatest reduction in hoary cress density during the year following treatment was obtained at the highest dosage level (5 lbs. per acre). In other experiments on uncropped land, reported elsewhere, 2.5 lb. per acre was near the optimum for hoary cress control in this period. It is possible that interception by the leaves of a covering crop may raise the optimum dosage level. However, the

effect of dosage level was temporary only and after the first year all levels gave similar results (Table II).

A second application of MCPA one year after the first greatly increased the degree of hoary cress control. The effect of this second spray was not influenced significantly by the dosage level of the first application. Since two relatively light applications effected a reduction of 70 per cent. three years after the second spraying, treatment of successive wheat crops offers possibilities for progressively greater yields of wheat, and eventual control of hoary cress.

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②

PRODUCTION OF ALLOPOLYPLOIDS IN PHALARIS BY A MODIFIED COLCHICINE TECHNIQUE

By E. M. HUTTON

Summary

Two sterile *F*₁ hybrids, *Phalaris tuberosa* x *Phalaris minor* and *P. caerulea* x *P. minor*, with 28 and 21 somatic chromosomes respectively have been produced. Hybridisation with the self-compatible *P. minor* as male parent was facilitated because *P. caerulea* was self-incompatible, and *P. tuberosa* almost so. By means of a new colchicine technique, fertile allopolyploids with 56 and 42 somatic chromosomes respectively were produced from the sterile *F*₁ hybrids. Spontaneous allopolyploidy occurred in *P. tuberosa* x *P. minor*. The project aims at developing quick growing perennial grasses adapted to short-term leys in the cereal areas of southern Australia or in colder pasture areas where winter production is a problem.

Introduction

A technique for intercrossing *Phalaris* species has been described by Jenkin and Sethi (1932), and Trumble (1935) reported the results from ten interspecific crosses in the genus *Phalaris*. Trumble's (1935) work on hybridisation between perennial and annual *Phalaris* species was not continued. The annual *P. minor*, although showing poor survival under grazing conditions, has a number of desirable characters. It is very palatable to stock, is quick growing and early maturing, and grows well under cold conditions when compared with the perennial species. *P. tuberosa* is an established pasture plant for use in permanent pastures, and *P. caerulea* is a perennial of distinct promise, so crosses between these and *P. minor* seemed desirable.

Characteristics of the parental strains and their hybridisation

Ten plants of a strain of each of the three species, *P. tuberosa*, *P. caerulea*

and *P. minor* were transplanted in early spring from the field to large pots in the glasshouse. One panicle of each plant was selfed by enclosing it in a cellophane bag before anthesis. Anthesis commenced at the top of the panicles, and in sunny weather reached a peak at approximately 8.30 a.m. in *P. minor*, 9.00 a.m. in *P. caerulea*, and 11.00 a.m. in *P. tuberosa*. The abundant pollen of *P. minor* was collected in a glass container and applied to successive groups of florets as they flowered on five selected panicles of each of *P. tuberosa* and *P. caerulea*. The method of crossing was similar to that of Jenkin and Sethi (1932). Emasculation and pollination of *P. caerulea* proved a little difficult, as only a proportion of the anthers and stigmas were exerted at anthesis.

At maturity four seeds of *P. tuberosa* x *P. minor* and 17 seeds of *P. caerulea* x *P. minor* were obtained. After the crossed panicles were harvested, two panicles were selected at random from each plant, and these and the selfed panicles were measured, the floret and seed numbers then being determined. Chromosome numbers were counted in squashes of seedling root-tips after Feulgen staining. The data are given in Table I.

The annual *P. minor* had the densest panicles and was highly self-compatible. It is apparent that *P. caerulea* was self-sterile, and *P. tuberosa* was almost

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TABLE I

Panicle characters, pollination habits, and chromosome numbers in three Phalaris species.

Species	Strain	Unbagged panicles			Mean No. seeds per selfed panicle	Chromosome No. $2n$
		Mean length cms.	Mean No. of florets per cm. of length	Mean No. seeds per panicle		
<i>P. tuberosa</i>	Australian Commercial	8.7	57.5	39.6	3.1	28
<i>P. caerulescens</i> ..	C.P.I. 9785	8.3	56.9	47.4	0.0	14
<i>P. minor</i>	Naturalised Canberra	5.0	84.6	258.1	267.4	28

so, and as a result the cross-pollination of these species with *P. minor* as the male parent was facilitated. The restricted air movement in the glasshouse no doubt contributed to the low seed set in open-pollinated panicles of the perennials.

The sterile F_1 hybrids and the production of allopolyploids from them

Three F_1 plants of *P. tuberosa* x *P. minor* and 17 of *P. caerulescens* x *P. minor* were raised, and as these were sterile they were propagated vegetatively. Chromosome numbers were counted in root tips. The clones of *P. tuberosa* x *P. minor* were perennial and were earlier and more vigorous than the parents. Figures 1 and 2 show the re-growth obtained in *P. tuberosa*, and *P. tuberosa* x *P. minor*, respectively, at the Dickson Experiment Station, Canberra. *P. caerulescens* x *P. minor* clones were annual and tended to be less vigorous than the parents.

In spring, plants of the F_1 clones were cut back 2 cm. from the base and painted with an excess of an aqueous solution containing 0.2 per cent. colchicine and 0.1 per cent. of the spreader, Gardinol K. Daily applications of the solution were made after cutting back the new growth

developed in the previous 24 hours. Six treatments were needed for growth to be obviously retarded. If plants were growing slowly treatments were better made on alternate days.

In the treated plants one or two seeds developed in 5 per cent. of the panicles. The plants raised from these seeds were fertile and were allopolyploids as evidenced by their somatic chromosome numbers relative to those of the F_1 hybrids (see Table II).

Chromosome numbers as high as 56 have not been reported previously in *Phalaris*. Plants of *P. arundinacea* with aneuploid numbers as high as 35 have been found by Hanson and Hill (1953). This species usually has a $2n$ number of 28, although

TABLE II

Somatic chromosome numbers of F_1 hybrids and induced allopolyploids of Phalaris.

	F_1	Allopolyploid
<i>P. tuberosa</i> x <i>P. minor</i>	28	56
<i>P. caerulescens</i> x <i>P. minor</i>	21	42



Figure 1.

Regrowth in *P. tuberosa* a month after rain at the end of summer.

I have found one strain (C.P.I. 7594) with 42. In addition seeds from *P. arundinacea* x *P. tuberosa* introduced to Canberra 15 years ago (C.P.I. 7033) now give plants with 42 chromosomes.

After a season's growth in the field it was apparent that in the new allopolyploid of *P. tuberosa* x *P. minor* desirable characters from both parents had been combined, whereas in that of *P. caerulea* x *P. minor* there was a tendency towards dominance of the *P. minor* characters. This was to be expected as *P. minor* contributed half the chromosomes in *P. tuberosa* x *P. minor* and two-thirds in *P. caerulea* x *P. minor*. The early vigour and tolerance to cold of *P. minor* was evident in both allopolyploids and to what extent this will be at the sacrifice of the perenniality and recovery after grazing of the other parents will only be determined by extensive trials.

Spontaneous allopolyploidy in F_1 *P. tuberosa* x *P. minor*.

Three hundred mature panicles from untreated plants of each F_1 hybrid were

threshed and two seeds were found in *P. tuberosa* x *P. minor*. These seeds gave allopolyploid plants. The pollen of the spontaneous and induced allopolyploids, the F_1 hybrids, and parents was examined after treatment with 1 per cent. iodine in 50 per cent. alcohol. In all except the F_1 hybrids there was a high percentage of stainable pollen. The F_1 hybrids had scant pollen, and in *P. tuberosa* x *P. minor* up to 20 per cent. was stainable, and in *P. caerulea* x *P. minor* up to 2 per cent. stained. The stained pollen grains were spheroidal and the greater diameter was measured (see Table III).

The results indicated a marked tendency towards spontaneous allopolyploidy, particularly in the F_1 *P. tuberosa* x *P. minor*, the pollen of which is shown in Figure 3.

Discussion

To increase the chances of obtaining valuable allopolyploids it may be neces-



Figure 2.

Regrowth in F_1 *P. tuberosa* x *P. minor* a month after rain at the end of summer.

TABLE III

Mean diameter in microns of stained pollen grains.

<i>P. tuberosa</i>	<i>P. caerulescens</i>	<i>P. minor</i>	<i>P. tuberosa</i> x <i>P. minor</i>		<i>P. caerulescens</i> x <i>P. minor</i>	
			<i>F</i> ₁	Allopolyploid	<i>F</i> ₁	Allopolyploid
41	39	37	51	52	45	45

sary to widen the range of gene combinations by intercrossing different strains of *P. tuberosa* and *P. caerulescens* with *P. minor*. In their work with the genus *Bromus*, Stebbins and Walters (1949) concluded that a large number of differ-

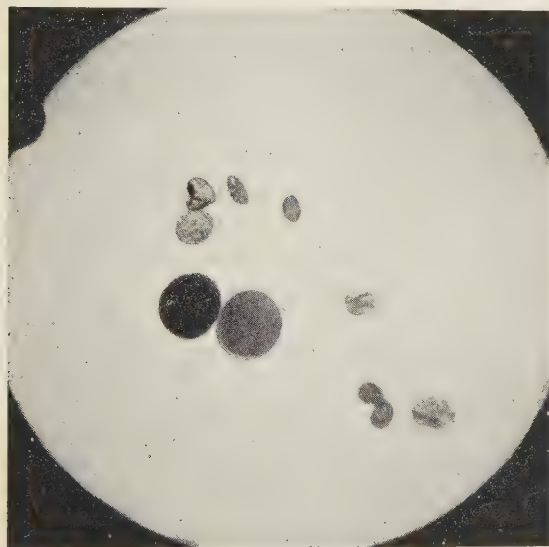


Figure 3.

Pollen of *F*₁ *P. tuberosa* x *P. minor* showing unstained shrivelled grains and two large stained grains.

ent allopolyploid combinations were needed in order to increase the gene supply and range of climatic and edaphic tolerance.

A feature of interest in this work has been the dilution of the perennality of the perennial parents in the *F*₁ hybrids and allopolyploids. The experiments have indicated that the order for the degree of perennality is *P. tuberosa* > *P. caerulescens* > *P. tuberosa* x *P. minor* > *P. caerulescens* x *P. minor*. All *F*₁ clones of *P. caerulescens* x *P. minor* had an annual habit when grown in the field and needed the glasshouse environment to demonstrate that they possessed a degree of perennality.

Acknowledgments

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PHYSIOLOGIC RACES OF SUBTERRANEAN CLOVER RUST

By B. D. H. LATTER

Summary

The occurrence of two physiologic races of subterranean clover rust in Australia, differing markedly in host range and field distribution, is discussed.

Introduction

Leaf rust of subterranean clover, caused by the fungus *Uromyces trifolii subterranei*, is known to cause serious reductions in grazing potential during seasons favourable to its development. Subterranean clover varieties resistant to the disease are known, but in general their yielding capacity is not high, and the most widely sown strains are rust-susceptible. The incorporation of rust-resistance into prolific commercial varieties could therefore be expected to lead to a significant increase in pasture production.

A satisfactory technique for the hybridization of subterranean clover varieties has been developed by McMillan (1937). In addition, Loftus Hills (1944), from field observations of the F_2 generation of a cross between Mt. Barker and the immune early-maturing variety Mulwala, concluded that resistance to leaf rust is an inherited character, and that a variety could probably be evolved combining the desirable agronomic characters of Mt. Barker and the rust-resistance of Mulwala. The breeding of a rust-resistant commercial variety, however, must be based on an understanding of the physiologic specialization shown by the rust fungus, and on details of the reactions of available varieties to each physiologic race. The present study has been concerned with these aspects of the problem.

Experimental Procedure and Results

Rust isolates were obtained from 27 localities throughout the subterranean

clover areas of Australia. Cultures of the isolates were maintained on seedlings of the variety from which they were collected, and were used in the systematic testing of 66 subterranean clover varieties under glasshouse conditions.* The rust reactions of individual plants within a given variety were found to be remarkably uniform, and observations made of pots of 15-20 seedlings of each variety provided a most satisfactory basis for comparative studies. The only exception was the variety Bacchus Marsh, which gave variable reactions to some isolates.

It was found that two distinct physiologic races of subterranean clover rust occur in Australia, and these have been designated races A and B. The two races differ markedly, both in their distribution throughout the subterranean clover belt, and in the reactions they induce in a number of varieties (Figure 1). In addition, a minor variant of race A has been detected from one locality in New South Wales. Details of the reactions of all varieties tested to races A and B are given in Table I, where "S" is used to denote susceptibility, "SR" to denote semi-resistance, "R" to denote resistance, and "I" to denote complete immunity.

Race A was found to occur in New South Wales, Victoria, Tasmania, South Australia and Western Australia. Race B, on the other hand, was detected only at four localities in Victoria, and at Bom-bala on the Southern Tableland of New South Wales.

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*Further details of experimental technique are given elsewhere (Latter, 1952).

TABLE I.
Reactions of Varieties of *T. subterraneum* L. to Physiologic Races of *U. t. subterranei*.

Variety	Reaction to		Variety	Reaction to	
	Race A	Race B		Race A	Race B
Amber-seeded Mt. Barker	S	S	Mt. Barker	S	S
Bacchus Marsh	R & S	S	Mulwala	I	I
Bass	SR	S	Muresk	R	S
Baulkamaugh North	I	I	Nangeela	R	S
Bena	S	S	New Northam Early	SR	S
Benalla	S	S	Northam	SR	S
Berlin	R	S	Orford	S	S
Burnerang	S	S	Pahantamu	SR	S
Burnley	S	S	Phillip Island	SR	S
Casterton	R	S	Pink Flowered	SR	S
Clare	R	S	Port Fairy	S	S
Cranmore	S	S	Portugal	S	S
Daliak	R	S	Portugal A	R	S
Derrinal	R	S	Redleaf	S	S
Dwalganup	SR	S	Romsey	S	S
Edenhope	S	S	Rouen	R	S
Flinders	R	S	Ruakura Farm	R	S
Gin Gin	R	S	Ruakura Selection	R	S
Hexham Hairy Stem	R	S	Samaria	R	S
Hexham Smooth Stem	R	S	Seaton Park	S	S
Hill's Small Seeded	R	S	Smeaton	R	S
Horsham	R	S	Springhurst	R	S
Kilmore	R	S	Tallarook	S	S
Kyabram	S	S	Turkish	R	S
Kybybolite	S	S	Wallendbeen	S	S
Kyneton	R	S	Wangaratta	S	S
Lake Midgeon	S	S	Wenigup	R	S
Leige	SR	S	White-seeded Mt. Barker	S	R
MacArthur	S	S	Williams	R	S
Madrid	S	S	Wodonga	R	S
Mansfield	S	S	Yabba North	R	S
Merino	S	S	Yarloop	R	S
Milton	SR	S	Yea	R	S

See text for explanation of Symbols.

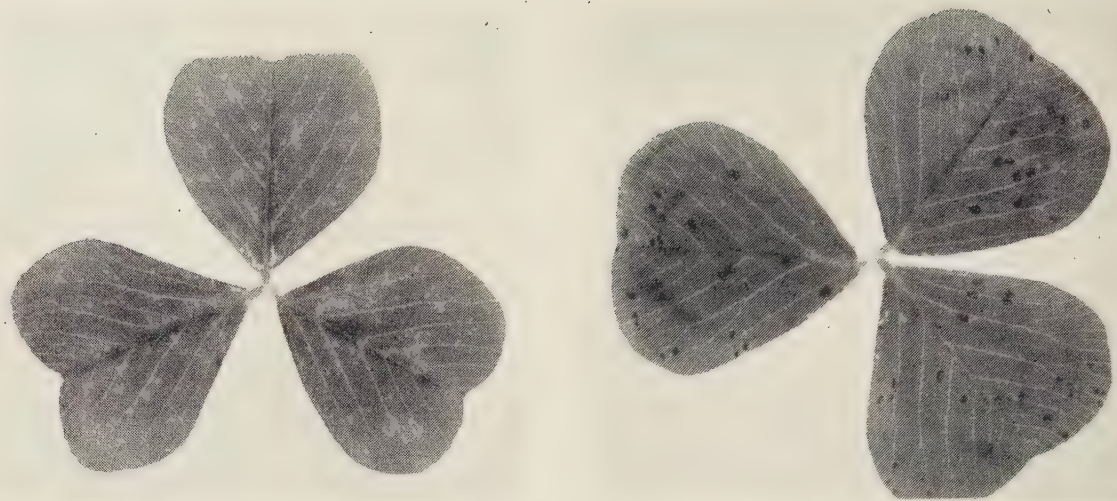


Figure 1.
Reactions of the variety Yarloop to races A and B.

(a) Small hypersensitive "flecks" denoting strong resistance to rust race A;

(b) Well developed pustules of rust race B on the same variety.

Discussion

The available evidence indicates that race B is at present restricted to Victoria and Southern New South Wales. Presumably the race has arisen in Victoria during recent years, its greater aggressiveness than race A having resulted in a progressive widening of its distribution. We must therefore be prepared to admit the likelihood of its ultimately spreading to all subterranean clover areas in Australia, and recognise the role it must play in future breeding programmes. Reliance on "field exposure" techniques in States other than Victoria must markedly reduce the potentialities of resulting resistant commercial varieties.

From Table I it is apparent that only three of the varieties tested possess resistance to both races of the pathogen, namely, Mulwala, Wenigup, and Baulkamaugh North. The potential value of these varieties as resistant parents in breeding programmes is therefore obvious.

A great deal more must be learned before our knowledge of the race position

in Australia is complete. Intensive surveys of each State should ideally be made annually to provide information on the distribution of all existing physiologic races, and to detect any future variants which may arise. The most urgent problem arising from the present investigation is that of the distribution in space and time of rust race B.

Acknowledgments

The author wishes to record his appreciation of the continued encouragement given by Professor W. L. Waterhouse. Thanks are also due to all those who co-operated in this study by forwarding rust material.

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THE EFFECT OF VIRUS X ON YIELD OF POTATOES— AN ASSESSMENT

By D. O. NORRIS

A number of workers have demonstrated by experiment that infection with virus X reduces the yield of potatoes. A brief summary of these experiments is shown in Table I. The great variability of the estimated loss is immediately apparent. In only one experiment, that of Clinch and McKay (1949), could no reduction of yield be shown when variety Up-to-Date was infected with mild strains of the virus. It is possible that under certain exceptional circumstances a tolerant variety might show such a slight reaction to a mild strain that yield reduction could not be demonstrated. However, the weight of evidence in Table I makes it quite clear that under usual conditions infection will cause a loss of yield that may be anywhere between 5 and 75 per cent. according to strain of virus X, variety of potato, and a number of other variable factors.

In Australia considerable attention has been devoted to selecting virus X-free (FX) stocks of the major commercial varieties (Bald and Norris, 1941; Bald, 1944a, b). Having succeeded in obtaining X-free stocks of three major Australian varieties, Up-to-Date, Bismark and Snowflake, Bald set out to prove the superiority of these stocks over commercial infected stocks. A series of comparative yield trials was made in the 1943-44 season at several localities, using the variety Up-to-Date which was the only one available in sufficient quantity at that time. In each of these trials a number of clones of X-free Up-to-Date were compared with the best X-infected certi-

fied seed. The X-free stocks showed gains over the certified stocks of between 14 and 27 per cent., "except in one instance, where there was evidence of an effect of the source and condition of the seed tubers on yield. In this trial the yields of three FX clones grown from seed tubers from another district were less than that of local X-infected certified seed" (Bald, 1944a, p. 259). It is possible that the failure of the X-free stocks to outyield the X-infected stock in this instance could result from intensive selection of the commercial stock for its local environment. Up-to-Date is well known to be an agronomically mixed variety (Bald, 1944a) and it is feasible that a line could be so selected for its local environment that, despite a reduction in yield due to virus X, it would still outyield an X-free line introduced from another district. Replacement of such a high-yielding local line with lower yielding but X-free stock would represent no material advantage, however praiseworthy from the point of view of sanitation.

This point has been stressed by Bawden, Kassanis and Roberts (1948) who remarked:—

"Perhaps the most interesting result of the yield trial (quoted in Table I of this paper) is that the Stock Seed Majestic, in spite of being infected with an avirulent strain of virus X, yielded

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TABLE I
Summary of experiments on effect of virus X on yield.

Per cent. reduction in yield.	Variety of Potato	Location of experiment.	Type of virus X used.	Authority
30	President	Australia	Medium	Bald and Norris, 1940
13.25	Up-to-Date			
16.00	Majestic	Scotland	Mild	Scott, 1941
28.4	Arran Chief	"	"	"
27.0	Majestic	"	Medium	"
11-13	Arran Chief	"	"	"
12.5	Up-to-Date	Australia	Mild	Bald, 1943
40-45	Great Scot	"	"	"
11.0	Up-to-Date	"	Severe	"
17.0	Up-to-Date	"	Mild-medium	" 1944, b
13-14	"	"	"	"
12-22	Chippewa	U.S.A.	Medium?	Schultz and Bonde, 1944
9.0	Katahdin	"	"?	"
12.0	Green Mountain Seedling	"	"?	"
	Nine varieties	England	Mild	Smith and Markham, 1945
Reduced but not significant	Majestic	"	X ^M (very mild)	Bawden, Kassanis and Roberts, 1948
18.6	"	"	X ^B (mild)	"
24.0	"	"	X ^Y (medium)	"
Reduced but not significant	Arran Banner	"	X ^M (very mild)	"
"	"	"	X ^B (mild)	"
"	"	"	X ^Y (medium)	"
21.8	"	"	X ^N (strong)	"
12.0	Up-to-Date, Clone I	Ireland	Mild strain I	Clinch and McKay, 1949
8.0	"	"	Mild strain II	"
Nil	Up-to-Date, Clone II	"	Mild strain I	"
Nil	Up-to-Date, Clone II	Ireland	Mild strain II	"
6.3	Katahdin, Chippewa	U.S.A.	?	Wilkinson and Blodgett, 1949
Reduced but not significant	Sebago			
	Chippewa, Sequoia	"	Very mild	Lombard, 1950
	Sebago			
9.5	Teton	"	"	"
74.0	Ackersegen	Germany	?	Klinkowski, 1951
43.0	Voran	"	?	"
11.0	"	"	?	"
Reduced but not significant	Placid	U.S.A.	Very mild	Roberts, Blodgett and Wilkinson, 1952
7.2	Up-to-Date, Bismark	Australia	Mild-medium	Norris, this paper

better than the virus-free plants, though the increase is not statistically significant. One explanation of this may be that the virus-free stocks were suffering from the effects of continued propagation under glass, and that longer than one year in the field may be needed to mitigate this condition. However, it is equally possible that there are differences of vigour and cropping power within potato varieties. . . . There is no doubt that most of the variations in cropping power of different stocks of one potato variety are determined by viruses, but it would be unjustifiable to assume that there are no other causes, and that a virus-free plant of one variety must of necessity crop better than one that is virus infected. Variations within potato varieties that affect foliage type and habit of growth, for example, bolters and wildings, are common. They presumably arise because of somatic mutations, and there is no reason to believe that mutations may not also occur that affect cropping power without producing any change in foliage characters. We have examined clonal lines of the variety May Queen, supplied by Mr. A. Beaumont, which varied in height, vigour and maturity, but could detect no virus in any by inoculation tests to tobacco and *Datura stramonium* or by grafting to other potato varieties. Thus in searching for new clonal lines to replace the existing commercial potato stocks freedom from virus X, although a primary consideration, should not be the only criterion, and before such lines are widely developed they should be shown to be at least as desirable in respect of other agronomic characters as the best stocks now in cultivation."

There is a second feature of FX stocks which deserves consideration. X-infection causes a slightly earlier maturity of the infected stock (Scott, 1941; Bald, 1943; Klinkowski, 1951). A delay in

maturity of only one or two weeks as a result of using a healthy stock might sometimes be detrimental in an area where the old X-infected stock is closely adjusted to its environment. For instance, it might mean that the crop has to finish badly under progressive desiccation if running into a dry season, or conversely that digging is deferred dangerously close to the time when heavy rains are normally expected.

These aspects have given rise to doubt in Australia of the wisdom of wholesale replacement of existing certified stocks with the available FX material. Such objections can be met only if the element of chance is removed from the obtaining of those stocks, that is, if we can select our starting material from the most desirable X-infected stock available and deliberately free it from X by some means such as chemotherapy. This seemed but a remote possibility until recently, but a technique for doing it has now been evolved (Norris, in press) and may provide the answer to many problems in this field.

The yield trials made by Bald, with the exception mentioned earlier, proved that, in general, X-free stocks were superior to commercial infected stocks. However, these trials all had one feature in common, that is, they were comparisons of an X-free stock with an unrelated X-infected stock. For the reasons just discussed, the figure of loss obtained might not truly represent the effect of virus X alone. It seemed desirable to demonstrate once again with Australian material the loss of yield due to X-infection, and to do this by deliberately infecting portion of an X-free clone and comparing it with its own healthy clonal material. With this objective the experiment summarised at the end of Table I was made in Canberra in the 1951-52 season. Great care was taken throughout the experiment to eliminate all sources of variation other than X-infection. The virus used was the complex of mild to medium strains

normally present in the variety Up-to-Date in New South Wales. A yield reduction of 7.2 per cent. was demonstrated.

There remains then no question that the presence of virus X in potato varieties considerably lowers the yield potential. The amount of loss is obviously a function of both strain of virus and variety of potato. There are mild and severe strains of virus and there are tolerant and intolerant varieties of potato. Not so obvious, but probably of great importance, is the environment in which the plants grow. In this connection the observations of Bald (1942 and 1944b) are relevant. He found that, with *Datura stramonium* grown under the poor light conditions of winter, X-infection had a large and significant effect on growth, but under summer conditions of high light intensity the effect was slight. To explain this, Bald postulated that virus multiplication is a partial substitute for the synthesis of chromo or chlorophyll protein and that during periods of high light intensity these proteins are accumulated as inert material beyond the minimum requirements for photosynthesis. Thus, during periods of high light intensity there is sufficient chromoprotein for both virus multiplication and photosynthesis but in times of light deficiency virus competition reduces the chromoprotein level below that required for normal photosynthesis, and loss of yield results. Bald examined the application of this hypothesis to the development of differences in yield between healthy and X-infected potatoes in two careful experiments (Bald, 1944b). He concluded (p. 273) that "there are now good grounds for assuming that the yield of tubers depends at least as much on the protein metabolism of the potato plant as on the carbohydrate metabolism, and that the amount of labile protein in the plant is more likely to limit the yield of plants infected with mosaic diseases than the amount of available carbohydrate."

There are two inferences one may draw from this work. First, it might well be expected that virus X infection will cause smaller losses of yield in environments where the crop is normally exposed to intense sunlight during its growing period than in those where cloudy conditions prevail, e.g., in Australia as compared with Scotland. The relatively low figure (7.2 per cent.) for reduction of yield obtained in the experiment described in this paper might reflect the fact that over most of the growing period of the crop exceptionally hot, sunny conditions prevailed. Second, it may be inferred that losses in yield from virus X are more likely to develop right at the end of the plant's growing period as a consequence of the "freezing" of some of the protein reserves as virus protein and the inability of the plant to re-convert the virus into substances that can be translocated and stored in the tuber. If this is true, any comparative yield trial in which normal maturity of the plants is prevented by such factors as blight or frost is to be regarded with reserve as it would undoubtedly result in an under-estimate of the effect of virus X. The variable effects of virus X on yield reported in different parts of the world might be partly explicable on this basis.

Even assuming that under Australian conditions the loss in yield is of the order of 5-10 per cent., and not in the 20-74 per cent. range, the cumulative loss of yield from infection of a good portion of the potato stocks must be very great. In Australia there are still grown large areas of the varieties Brownell (Adirondack), Delaware (probably Earliest-of-All) and Carman (probably synonymous with Green Mountain) which are X-saturated. As long as these varieties continue to hold a significant place in the potato economy, efforts to free them from virus X by techniques such as chemotherapy of sprouts will be justified, provided that starting material is selected from the best-yielding strains available.

Ultimately these varieties may be displaced by varieties resistant or immune to X. The work of Hutton (1951) and Hutton and Wark (1952) has laid the foundation for such varieties suitable to Australian conditions. However, at the moment there is a strong trend in Australia to replacement with the newer American potato varieties such as Sebago. For instance, in New South Wales in 1952 the varieties Sebago and Sequoia together occupied over 50 per cent. of the certified acreage, Saranac was third in importance, and Up-to-Date fourth. Some of these varieties have a limited field resistance to X infection. Schultz and Bonde (1944) stated that "Katahdin rarely contracts latent mosaic in the field." Lombard (1950) stated that "a few varieties, including Kennebec, Katahdin, Sebago, Teton and Menominee, are somewhat resistant." This resistance, however, is insufficient to prevent the ultimate infection of stocks if no care is taken to protect them. In the same paper, Lombard presented the data shown in Table II for infection of commercial stocks based on the indexing of 100 tubers of each variety.

TABLE II

Percentage of virus X in commercial stock

Variety	Virus X		
	Strong X	Mild X	Healthy
Chippewa	86	14	0
Sequoia	74	14	12
Sebago	68	14	18
Teton	28	24	48

A scheme for the maintenance and multiplication of FX stocks of potatoes on a national basis was set up in Australia in 1944 (Bald, 1944a) but was abandoned after a short time. At present little note is taken in Australia of virus X in potato

crops with the exception of Tasmania where X is controlled in certified stocks by single-plant selections and multiplication in stages under strict supervision. A small survey made by the author in 1952 indicated that commercial stocks of the newer varieties in the Crookwell area of New South Wales are not as yet heavily infected. Average infections found were: Sebago, 2 per cent.; Sequoia, 4 per cent.; and Saranac, 5 per cent. By contrast, Up-to-Date, issued virus-free six years previously, was found to be carrying 41.5 per cent. infection, indicating a high degree of susceptibility compared with the American varieties. It also indicates strikingly the potential danger of the situation. If a susceptible variety can in six years accumulate 41.5 per cent. infection it is obvious that conditions must be favourable for X-transmission, and that X-infection of the newer varieties, though slower because of their higher resistance, will steadily accumulate. A disquieting feature of these newer varieties is that they seem to have a tendency to accumulate strong ringspot strains of virus X which affect the yield much more than the milder strains found in such varieties as Up-to-Date (Ladeburg, Larson and Walker, 1950; Hutton, unpublished data).

Should old infected varieties be reconstituted by chemotherapy they will require extra vigilance to keep them in a virus-free condition. The very fact that they are saturated with virus X indicates that in the past they must have been particularly susceptible to infection. It will be necessary also to watch the progress of infection in Australian stocks of the newer varieties, and to take action should they at any time approach a content of virus X comparable with those quoted by Lombard. In either event it will undoubtedly be economically worthwhile to re-establish some form of FX potato scheme.

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②

THE RELATIVE EFFICIENCY OF 2, 4, 5-T AND A MIXTURE OF 2, 4, 5-T AND 2, 4-D IN THE CONTROL OF BLACKBERRY BRAMBLE

By B. D. ROBINSON and W. T. PARSONS

Summary

A method of carrying out accurate experimental work on the control of Blackberry bramble is outlined.

Plots were treated with 2,4,5-T, 2,4-D and a mixture of 2,4,5-T and 2,4-D.

2,4-D alone has no significant effect on the control, whereas 2,4,5-T alone gave highly significant control.

Adding 2,4-D to 2,4,5-T does not increase the efficiency of the 2,4,5-T in the flowering to fruiting stage of growth.

At certain rates the addition of 2,4-D to 2,4,5-T decreases the efficiency of the 2,4,5-T.

Increasing the rate of application of 2,4,5-T beyond 1 lb./ac. does not significantly increase the percentage kill under the conditions of this trial.

Introduction.

Blackberry bramble (*Rubus fruticosus* L.) is a native of Europe which has been introduced into Victoria where it is now established as a troublesome weed in the high rainfall areas. Unless constantly kept in check it spreads rapidly in the rich dairying and other agricultural land of Gippsland and the Otway Ranges in particular. It is a proclaimed noxious weed under the Vermin and Noxious Weeds Act 1949 for the whole State of Victoria, and as such it becomes the responsibility of the Victorian Department of Lands and Survey to enforce its control. It is also proclaimed in Tasmania, New South Wales, Queensland and South Australia.

It has been shown that cultivation, combined with the sowing of permanent pastures and annual top dressing, is effective in controlling this weed (Prunster, 1940; Meadly, 1944). In places where cultivation cannot be practised, such as road-

sides, river frontages and Crown lands, control has been attempted by constant cutting or by spraying with arsenic or chlorate type weedicides. None of these treatments had any appreciable effect in reducing the vigour or density of the stands unless tediously persevered with. (Meadly, 1944).

With the advent of hormone type weedicides it was shown (Anon. 1949) that, under Australian conditions, a kill of up to 90 per cent. could be obtained with one application of compounds containing 2,4,5-T (2,4,5-Trichlorophenoxyacetic acid). Most of the original commercial preparations recommended for blackberry control contained a mixture, in equal proportions, of 2,4,5-T and 2,4-D (2,4-Dichlorophenoxyacetic acid). It was thought that although 2,4,5-T alone was effective, the mixture of 2,4-D and 2,4,5-T was cheaper for equal phytotoxic efficiency when compared on an acid equivalent basis (2,4-D is approximately half the cost of 2,4,5-T).

In view of the economic importance of blackberry control in Victoria it was decided to carry out experiments to determine the relative effectiveness of 2,4-D in mixtures with 2,4,5-T for controlling blackberry.

Experimental Procedure.

Blackberry is a difficult weed to experiment with because of the impracticability of

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bility of determining plant density by any of the normal methods. In the past most trials on this weed have been carried out on dense stands, where it is impossible to have accurately measured plots without cutting tracks through the growth before spraying. Even if tracks are cut before spraying, the experiment loses some of its significance because of the unnatural conditions created. Also with a dense stand divided into plots, the edge effects are difficult to assess and eliminate.

In this experiment it was decided to use a long natural strip of blackberries which could be readily divided into the required number of plots along its length. Apart from simplifying the laying out of plots this type of growth is usually very uniform in density and past history. Also such plots would have edge effects on two sides only.

A suitable growth along a fence line about 15 ch. long was chosen on a Red Loam (Krasnozem) soil type at Menzies Creek in the Dandenong Ranges, approximately 30 miles east of Melbourne. The surface soil in this area is a red brown clay loam of pH 5.3. This is a high rainfall area (av. R.F. = 47-50 in.) and is particularly suited to vigorous blackberry growth. For many years the growth had been controlled either by cutting, rolling or burning spasmodically, but had not been treated in any way for at least eighteen months prior to this experiment. The average height of the growth was 8 ft.

The strip of blackberries was no greater than 20 links wide at any point and the plots were thus made 20 x 20 lk. (= 1/250th ac.). A buffer strip three links wide was left between each of the plots to prevent drift affecting adjacent plots. It is considered that three links is a sufficient buffer if the spraying is carried out on a reasonably still day, as no signs of epinasty (distortion of leaves and stems) were found on adjoining control plots. All growth in the buffer strips was cut out after the spraying of the plots

so as to prevent the translocation of spray material from canes in one plot to their roots in an adjacent plot. The numbers of green canes were counted in the buffer strips (3 x 20 lk.) and these were used to give a measure of the initial cane density of the adjacent plots.

The plots were sprayed on the 21st and 25th of February 1952 using the ethyl ester of 2,4-D, butyl ester of 2,4,5-T and a mixture of these two in equal proportions. These formulations were specially prepared to ensure that they were comparable in emulsifying agents, emulsion characteristics and wetting effects. The applications were made at the rates of 0, $\frac{1}{2}$, 1, 2 and 4 lb. of acid equivalent per acre in 200 gal. of water per acre. A preliminary trial showed that 200 gal. of water per acre was sufficient to wet the foliage thoroughly without run-off. The fifteen treatments (three formulations at five rates each) were replicated in four blocks and randomized within each block.

Two blocks were treated on the 21st and two on the 25th of February and on both days the weather was fine and still with average temperatures of 62°F. and 75°F. respectively. No rain fell for at least 24 hours after each treatment. The growth stage at the time of spraying was between flowering and fruiting, with most fruit in the green to red stage. The spray was applied at a constant pressure of 40 p.s.i. through a 4 jet hand boom with an effective spray width of 5 links. Each plot was evenly sprayed in a constant time. No attempt was made to penetrate the clump with the spray as it would be impossible to give exactly the same treatment to each plot.

Twelve months after the initial treatments all growth was cut from the plots and counts were made of the number of green canes remaining in strips 10 x 20 lk. across the centre of each plot.

These figures were compared with the original density of the plot as calculated

TABLE 1.

Showing percentage survival of Blackberry Bramble (adjusted for natural decrease). Corresponding logarithmic values given in brackets.

Treatment	Rate (lb./ac.)			
	$\frac{1}{2}$	1	2	4
2,4-D (ethyl ester)	97 (1.987)	84 (1.926)	95 (1.977)	100 (1.999)
2,4,5-T (butyl ester) . .	58 (1.766)	23 (1.359)	20 (1.302)	29 (1.464)
Mixture	80 (1.903)	60 (1.779)	32 (1.503)	32 (1.501)

Significant difference between means — 5% level (0.175)

1% level (0.233)

from the densities of the adjacent buffer strips. This gave the percentage survival on each plot.

The application of the mixture of 2,4-D and 2,4,5-T has no significant effect on survival at the $\frac{1}{2}$ lb. rate but at the 1 lb.

Results and Discussion

Comparison of the densities on the buffer strips at the beginning of the experiment with the control plots twelve months later showed the final density to be 95.3 per cent of the initial density. This decrease is probably due to natural mortality. Hence for all other treatments the percentage survival was calculated as the ratio of the final density for the treatment to the initial density of the corresponding strips multiplied by $100^2/95.3$. The percentage survivals for the different formulations and rates of application are given in Table 1.

For statistical purposes the percentage survivals are expressed as logarithms and these are used for determining the significance of the results.

It can be seen that none of the 2,4-D treatments has any significant effect on survival, whereas all rates of 2,4,5-T used have a highly significant effect in reducing the percentage survival. With 2,4,5-T the 1 lb./ac. is significantly better than the $\frac{1}{2}$ lb./ac. but increasing the rate beyond 1 lb./ac. does not have any further effect in decreasing the percentage survival.



Figure 1.

Four-jet boom moving over the growth. Note tapes defining buffer strip.

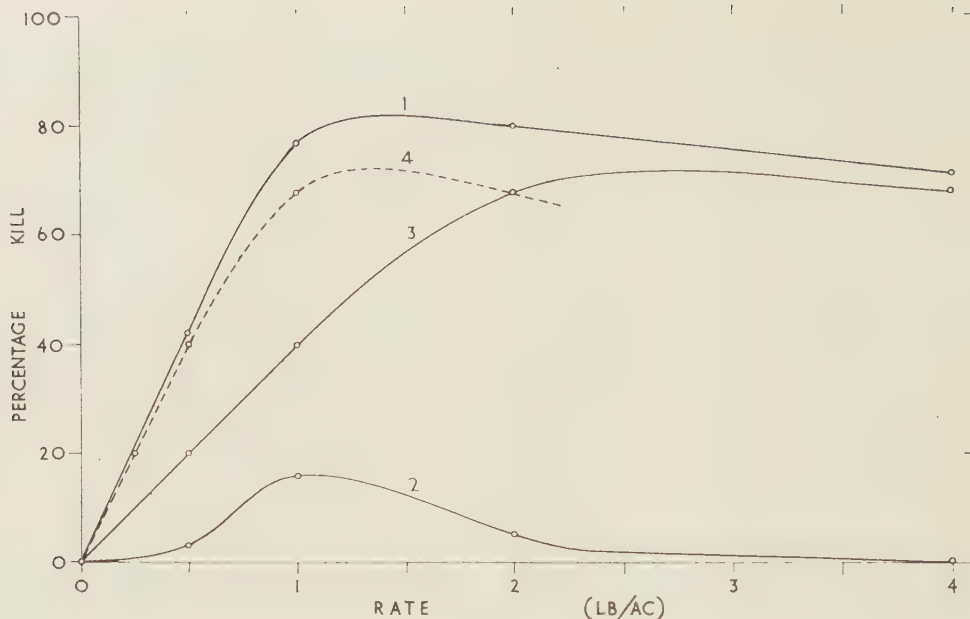


Figure 2.

Graphs showing the relation between percentage kill of *Rubus fruticosus* L. and rate of application of hormone type substances.

1. 2,4,5-T alone.
2. 2,4-D alone.
3. Mixture of 2,4,5-T and 2,4-D.
4. 2,4,5-T in the Mixture of 2,4,5-T and 2,4-D

rate there is a significant decrease in the survival (5 per cent. level). The 2 lb. rate is significantly better than the 1 lb. rate (1 per cent. level) but increasing the rate beyond 2 lb./ac. does not decrease the percentage survival.

The percentage survivals with the $\frac{1}{2}$ and 1 lb. rates of 2,4,5-T do not differ significantly from the 1 and 2 lb. rates respectively of the mixture. However the 2 lb. rate of 2,4,5-T gives a significantly lower percentage survival (5 per cent. level) than the 4 lb. rate of the mixture.

It should also be appreciated that the mean of the percentage survivals of the 1 and 2 lb. rates of 2,4,5-T gives a significantly lower value than the mean of the percentage survival of the 2 and 4 lb. rates of the mixture. It is apparent from these results that the addition of 2,4-D to the 2,4,5-T has decreased the efficiency of the 2,4,5-T.

The percentage kills (100 per cent. survival) are shown in the graphs in Figure 2.

Graph 4 has been drawn on the basis of the 2,4,5-T content in the mixture as shown in graph 3 (i.e. 1 lb. of the mixture is expressed as $\frac{1}{2}$ lb. of 2,4,5-T).

Comparison of graphs 1 and 4 demonstrates the reduction in the efficiency of the 2,4,5-T by the addition of 2,4-D. If this was not so curves 1 and 4 would coincide.

Conclusions

The following conclusions can be drawn from a study of Table 1 and Figure 2.

1. On its own 2,4-D had no significant effect on the control of Blackberry bramble (*Rubus fruticosus* L.).

2. The effect of 2,4,5-T increases up to the 1 lb./ac. rate but beyond this rate of application there is no significant increase in kill.

3. The addition to 2,4,5-T of an equal quantity of 2,4-D has no significant effect in increasing the kill. On the contrary, at certain rates the addition of an equal volume of 2,4-D to 2,4,5-T reduces its effectiveness (significant at 1 per cent. level for the mean of 1 and 2 lb./ac. of 2,4,5-T). See Graphs 1 and 4, Figure 2.

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②

THE COMPARATIVE RESISTANCE OF SOME POTATO VARIETIES TO COMMON SCAB

Common scab of potatoes (*Solanum tuberosum* L.) due to *Streptomyces scabies* (Thaxter) Waksman and Henrici, is not regarded as a disease of major economic importance in Australia, but does occur in some localities and may cause serious losses in some seasons (Noble, *et al.*, 1937; Simmonds, 1938). Resistant varieties developed overseas have found no place in the potato industry in Australia. The work reported here was undertaken to determine whether available potato varieties were sufficiently resistant under a wide range of conditions of soil and climate to provide a starting point for a breeding programme.

Materials and methods

Field experiments were located in five Australian States and extended over four seasons, 1947-48 to 1950-51. The following eight varieties and lines were tested:—Cayuga and Ontario, reported as highly resistant in America by Blodgett and Stevenson (1946); three resistant Canadian seedling lines, 1537-12, 1413-119 and 1523-11 (obtained from the Central Experiment Farm, Ottawa); and Late Carman, Sebago and King Edward, which are grown commercially in Australia. The highly susceptible variety Late Carman was the standard for comparison.

Each experiment included four to eight replicates of each variety, each replicate consisting of a row of ten plants at intervals of two feet, with a space of three feet between rows. Tubers in all plots were treated with a solid or liquid inoculum of *S. scabies* except at Mowbray Swamp, Tasmania. Crops grown there

are normally heavily infected and artificial inoculation was considered unnecessary.

Liquid inoculum, used in South Australia, Victoria and Queensland, consisted of pure cultures of the pathogen suspended in skim milk. Seed tubers were inoculated by dipping for one minute immediately before planting. Solid inoculum was used only at Dickson, A.C.T. A quantity of soil was artificially infested in advance by incorporation of infected haulms and scabby tubers from the previous season and frequent addition of tap-water suspensions of virulent cultures of *S. scabies*. At planting, the inoculum was applied directly to the seed at the rate of one pound per tuber.

Results and Discussion

As each variety reached maturity, it was dug and sixty tubers were selected at random from the bulked yield of the ten plants in each replicate. These were washed, air-dried and rated for disease incidence. To determine the better method of estimating degree of injury, two sets of ratings were made. Severity of infection was determined by rating each tuber 0 to 4 according to severity of scab lesions, regardless of the proportion of surface area affected. This method has been described by Leach *et al.* (1938). Extent of scab was determined as a percentage of tuber surface covered with scab lesions by comparison with the chart of standards used by Clark *et al.* (1938). Figures obtained from each method of rating have been analysed, and the results of all experiments, and corrected means for each variety, are presented in Tables I and II.

TABLE 1.
Severity and extent of scab infection

Severity and extent of scab infection																																
	Dickson, A.C.T. (solid inoculum)						Rendelsham South. Aus. (liquid inoculum)						Koo- Wee- Rup Vic. (liquid inocu- lum)						Mowbray Swamp Tasmania (no inoculum- scab infested area)						Lawes, Queensland (liquid inoculum)						Mean S corrected for mode of inoculation, season and place	Mean % corrected for mode of inoculation, season and place
	48-49		49-50		50-51		47-48		48-49		47-48		47-48		48-49		47-48		48-49		Spring 1948		Aut'mn 1949		Spring 1949							
	S	%	S	%	S	%	S	%	S	%	S	%	S	%	S	%	S	%	S	%	S	%	S	%	S	%						
Cayuga	1.8	31.2	1.3	18.1																	0.3	0.8	0.6	4.7	0.4	2.5	0.61	5.5				
Ontario	1.3	22.9	0.7	12.5	0.9	12.6			0.1	1.1											0.4	1.2	0.9	0.7	5.4	0.7	4.2	0.58	4.4			
1537-12	1.9	43.4	0.8	11.5			0.1	0.4	0.1	0.4	0.1	0.2			1.0	14.7	0.5	1.7	0.3	1.4	0.8	4.7	0.7	5.8				0.65	6.0			
1413-119	1.9	51.0	1.8	34.1			0.8	2.7	0.3	1.8					0.8	8.4	0.3	1.2						0.9	6.5				9.83	8.5		
1523-11	1.9	61.8					0.5	1.6	0.3	1.8	0.1	0.5	1.2	24.9	0.8	4.6	0.3	0.8	1.0	8.2								0.85	10.5			
Late Carman	2.9	73.3	2.4	27.9	2.2	37.0			1.0	3.7	1.0	3.5	2.5	69.2	2.1	13.5	1.9	11.0										2.04	24.4			
Sebago	2.8	65.8	2.0	29.8	1.9	19.2									1.3	7.3					1.7	9.8	1.1	8.8				1.59	14.2			
King Edward	2.4	34.9					0.8	2.6	0.8	3.4	0.3	1.0	2.5	49.6	1.4	3.7												1.44	12.2			

Legend: S = Severity of lesions, 0-4.

The numerical values for the percentages of surface carrying lesions, and for the ratings for severity were transformed using angular transformation. Constants were estimated for the effect of location, mode of inoculation and season and the mean varietal values determined, freed from mean location, mode of inoculation and season effects. Finally, tests of significance of differences were made for each varietal pair and are presented in Table 2.

TABLE 2.
Significance of Differences

	Mean S		Mean %		Ontario		1537-12		1413-119		1523-11		Late Carman		Sebago		King Edward	
					S		S		S		S		S		S		S	
	S	%	S	%	S	%	S	%	S	%	S	%	S	%	S	%	S	%
Cayuga	0.61	5.5			N.S.	N.S.	N.S.	N.S.	N.S.	5%	N.S.	N.S.	1%	1%	1%	5%	1%	N.S.
Ontario	0.58	4.4									N.S.	N.S.	1%	1%	1%	1%	1%	N.S.
1537-12	0.65	6.0									N.S.	N.S.	1%	1%	1%	1%	1%	N.S.
1413-119	0.83	8.5									N.S.	N.S.	1%	1%	1%	1%	1%	N.S.
1523-11	0.85	10.5									N.S.	N.S.	1%	1%	1%	1%	1%	N.S.
Late Carman	2.04	24.4									N.S.	N.S.	1%	1%	1%	1%	1%	N.S.
Sebago	1.59	14.2									N.S.	N.S.	1%	1%	1%	1%	1%	N.S.
King Edward	1.44	12.2									N.S.	N.S.	1%	1%	1%	1%	1%	N.S.

Legend: S = Severity of lesions.

% = Percentage of surface carrying lesions.
N.S. = Not significantly different from each other.
1% = Significantly different from each other at the 1% level.
5% = Significantly different from each other at the 5% level.

Of the two methods, more significant results were obtained by estimating severity of scab lesions. It is possible that some varieties subject to the disease have much of their tuber surface affected by lesions of a superficial nature. Rating on a severity basis only would indicate, incorrectly, that such varieties are scab resistant. Many instances of this type of infection were observed when rating tubers of seedling 1523-11. Conversely, King Edward sometimes gave the opposite reaction. It should be emphasised that even a small number of scab lesions, whether deep or superficial, can greatly detract from the appearance of commercial potatoes and may be the cause of affected samples being downgraded. It is clear then that neither method of rating will, by itself, give satisfactory results for all varieties, and that to obtain a true picture of potential scab resistance a combination of both methods must be used.

In experiments where inoculations were made with skim milk suspensions of *S. scabies*, the degree of induced scabbiness was not greatly in excess of normal commercial incidence. At Dickson, A.C.T., where infested soil was used as inoculum, scab infection was far more severe than normally experienced in that area. Increased degree of infection did not alter the general trend of varietal resistance but had the advantage that relative differences were more marked.

Throughout these trials it was apparent that the resistance of the imported varieties and seedling lines, although high compared with the standard varieties, was still insufficient to prevent considerable losses by downgrading on the grounds of disfigurement alone. Additionally, although no comparison was made, it was obvious that the yields of

the resistant types were lower than Sebago and Late Carman. It is clear that they can find no direct place in the Australian economy and it is doubtful if their resistance is sufficient to warrant using them as the basis of a breeding programme. To obtain a hybrid potato with the good agronomic characteristics of the susceptible varieties, combined with high scab resistance, it would be necessary to use one parent with almost complete immunity to the disease.

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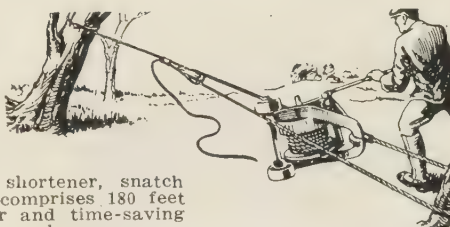
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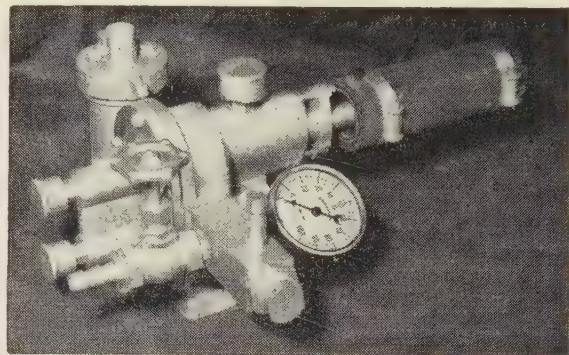
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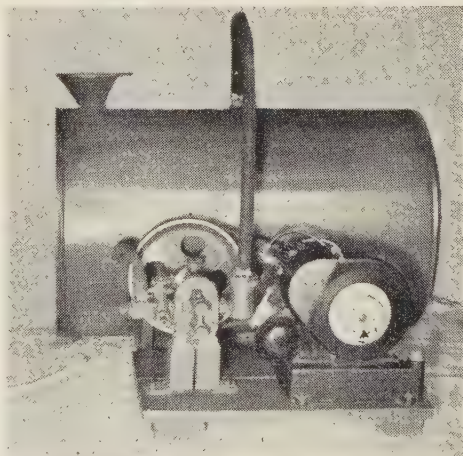
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POWER TAKE-OFF PUMP

$\frac{1}{2}$ gear pump supplies $3\frac{1}{2}$ gallons per minute at 500 r.p.m. All bronze construction fitted with stainless steel shafts.



ENGINE DRIVEN SPRAY OUTFIT

ENGINE UNIT

The outfit consists of 1 h.p. engine, gear pump, pressure relief valve, inlet filters and 44 gallon spray tank. The engine and tank are secured to suitable wooden base plate. Tank optional.

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COUNCIL PROCEEDINGS

The 133rd Meeting of Council was held in Adelaide at 7.15 p.m. on 23rd September, 1953.

Present

Dr. A. R. Callaghan (President, in the Chair), Dr. T. J. Marshall (Qld.), Dr. R. N. McCulloch (N.S.W.), Dr. H. G. Andrewartha (A.C.T.), Mr. L. R. Houlst (Vic.), Mr. H. K. Kemp (Tas.), Mr. D. S. Riceman (S.A.), Mr. N. R. McKeown (W.A.), and Mr. H. P. C. Trumble (Hon. General Secretary).

Hon. General Treasurer

The resignation of Mr. T. T. Colquhoun, temporarily transferred to Canberra, was accepted with regret, and Mr. P. C. Angove was appointed Hon. General Treasurer in his stead. Mr. Angove was welcomed to the meeting.

Central Secretariat

Dr. Callaghan reviewed the developments which had taken place since the last Council meeting. He outlined his approach to the Minister for Commerce and Agriculture (the Rt. Hon. J. McEwen) for assistance from the Commonwealth Extension Services Grant, so that the Institute might be able to establish a Central Secretariat on a trial basis and thereby help it in the realization of those of its aims which were in keeping with the aims and objects of the Extension Services Grant. If Commonwealth assistance were accepted, the Institute could assist, particularly in the matters of recruitment of schoolboys to agricultural studies and in raising the status of the profession in the public eye.

The Minister gave verbal approval to these proposals and the Chairman explained that, as a result of interrogation by the Minister, he had given his personal assurance that the Institute, in using the funds made available, would establish a Central Secretariat (if the Institute agrees) whose objects during the period of its trial, will be to meet the particular objects (i), (ii) and (iv) of the Memorandum of Association.

The Chairman made it quite clear that the Institute was not committed in any way by his approach to the Minister, but the way is now open for the Institute to avail itself of this financial assistance, if it so desires.

Events during August and September culminated in the present Council Meeting, when it was possible to submit a detailed budget for the establishment and maintenance of a Central Secretariat. The budget details, which had been evolved as a result of consultation between the Victorian Branch, the President and the Secretary, were submitted to Council, who agreed that

they should be immediately conveyed to principal delegates by the President.

The Chairman stated that two clear-cut steps were necessary if the Institute were to set up a Central Secretariat. These were:—

- (i) Amend the Articles of Association along the lines suggested by the Institute's solicitors, which would give the Council power to employ the officers who would staff a Central Secretariat; and
- (ii) Seek the approval of the Institute, through Council Members, to actually appoint a General Manager (or Secretary, as the case may be).

Reactions from Branches were received, although it was obvious that lack of details furnished so far gave most Branches some concern. General approval of the President's actions was registered, but further details were awaited.

After general discussion it was agreed by Council that the action taken to date be endorsed; that action be taken to secure the Amendment of the Articles of Association to allow the appointment of a Central Secretariat at an appropriate time; that a detailed statement of finance and proposed duties of a Central Secretariat be forwarded to Branches; and that, when the time came, Council appoint a sub-committee to carry out any decision of the Institute to establish a Central Secretariat.

Annual General Meeting

Arrangements are being made for holding the 21st Annual General Meeting of the Institute in Canberra on 11th and 12th January, 1954. A Joint Session with Section K of A.N.Z.A.A.S. is being arranged and efforts are being made to bring Dr. F. T. Wahlen, Director General of Agriculture in F.A.O., to Australia to address the Joint Session.

A.I.A.S. Text Book

Consideration was given by Council to the report of a sub-committee appointed to examine alternatives to Mr. P. J. Skerman's proposals. The report, which recommended the writing of text books on a State or Branch basis, rather than with the Australia-wide coverage planned by Mr. Skerman, was endorsed by three Branches and strongly opposed by three. The seventh Branch was not directly in favour of either school of thought, so no decision was possible.

Faced with such a division of opinion, Council felt that it had no alternative but to refer the matter for decision to delegates-in-person.

Australian Medal of Agricultural Science

A report by the Hon. General Secretary, suggesting alterations to the by-laws governing this

award, had been circulated. Branch comments were in favour of the suggestions which provide for a selection committee in place of the present system of preferential voting by Branch committees. Further suggestions relating to the membership of the committee and the rotation of members were referred to Branches for decision.

Rebates in Respect of Emeritus Membership

Branches were unanimously agreed that no rebate should be payable to Branches on account of Emeritus Members.

Registration of Increased Membership

The Institute's solicitors, acting on instructions from Council, have now registered an increased membership, providing for a maximum of 2,000. This required the appropriate alteration to the wording of Article 2 of the Articles of Association, which was made effective by a previous resolution of Council.

Victorian Branch Brochure—"Careers in Agricultural Science"

A dummy of this brochure, indicating its format, together with the Victorian manuscript, were tabled. Reactions from the N.S.W. and South Australian Branches indicated that they were prepared to adapt the manuscript to suit local conditions and place orders for printing this year. Advice from the other Branches was expected to be forthcoming as all had had the opportunity to examine the format and manuscript.

The President undertook to make an immediate formal application to the Department of Commerce and Agriculture for £500 to cover the costs of printing and publishing the brochure. Steps, in the meantime, were being taken by the Victorian Branch to have the brochure ready for distribution before the end of the school year.

Membership

Student Membership

With the recommendation of the Branch submitting the applications, the following applicants were admitted to **Student Membership**:—
Brooker, M. I. H., South Australia.
Buttrose, M. S., South Australia.
Messenger, J. J., South Australia.
Moore, R. W., South Australia.
Potter, J. S., South Australia.

Cancellation of Student Membership

With the recommendation of the Branch concerned, the following Student Memberships were cancelled:—
Adamson, D., New South Wales.
Barr, D. A., New South Wales.
Cusack, O. L., Queensland.
Davey, B. G., New South Wales.
Donovan, Miss K. O., New South Wales.
Giovannelli, J., New South Wales.
Lee, G. R., New South Wales.
Lynch, B. T., New South Wales.
Sheldon, B. L., New South Wales.
Young, Miss D. B., New South Wales.

Subscriptions Waived

With the recommendation of the Branch, the following subscriptions were waived for 1953:—
Acock, A. M., Victoria.
Gurnett Smith, A. F., Victoria.
Hackwell, A. B., Victoria.
Scharp, L. R., Victoria.
Tulloch, N. M., Victoria.
Walsh, J. C., Victoria.

Transfers

The following transfers were noted:—
Hutchinson, K. J., Queensland to South Australia.
McIntyre, A. J., Victoria to New South Wales.
Nihill, F. A., Tasmania to Victoria.

Reinstatement of Student Members

On the submission of the Queensland Branch, Messrs. L. A. Edye and R. A. Logan, whose Student Membership had been cancelled in error, were reinstated as Student Members.

BRANCH NOTES

Australian Capital Territory

Dr. P. S. Nutman, a member of the staff of Rothamstead Experimental Station, addressed a meeting of the Branch on Tuesday, 11th August, on the subject "Morphogenesis of Nodules in Legumes". After describing the method of entry of the *Rhizobium* bacterium into the host plant by way of the root hair, Dr. Nutman went on to speak of the differing types of nodulation and with particular reference to effective and ineffective strains and the distribution of the nodules on the root system of the host. The variation in the distribution of nodules on the root system of the host plant has been thought to be due to differences in virulence of the bacteria but the virulence theory has been found not to explain

all the known facts and leaves out of account the role of the host plant.

The plant can control infection by its inherent characteristics, one of which is its heterozygosity, which is favourable to nodulation. An effective strain contributes to an inhibiting effect on further infection, while, with ineffective strains, no such inhibition results. This was exemplified by the removal of up to 6 nodules in an experiment involving both effective and ineffective strains. Nodule numbers increased following removal of nodules in the case of the effective strain but not with the ineffective one.

The importance of the genetic make-up of the host plant becomes evident when the progenies of plants bearing large numbers of nodules have

been found to produce large numbers of nodules also. Dr. Nutman referred briefly to the antagonism between strains of *Rhizobium*. The number of nodules of a particular type present bear a relationship to the number of bacteria of that strain present in the medium.

The meeting held on 4th September took the form of a symposium on Ecology. Mr. R. M. Moore, Principal Research Officer, Division of Plant Industry, C.S.I.R.O., in introducing the subject, outlined the importance of the ecological approach for the understanding and solution of the varied problems from the simpler among the lower forms of life up to the most complex in man's social relationships. The greatest need of today is an ecological study of man as the dominant organism and of the competition between men of different communities. The ultimate goal is a universal human community in which man, though dominant, is a collaborator, and in which mutual adjustment takes precedence over competition.

Mr. C. S. Christian, Officer in Charge, Land Research and Regional Survey Section C.S.I.R.O., Canberra, in speaking of the importance of ecology in relation to land use, stressed the necessity of thinking continuously in terms of interaction of factors which are involved to varying degrees of complexity. In applying ecological thought to the assessment of land potential the first task is to describe and classify the environment in terms of rainfall, vegetation, climate, soil and soil fertility. Mr. Christian went on to demonstrate the importance of the ecological approach in regard to each of these factors.

Dr. M. R. Jacobs, Principal of the Australian Forestry School, Canberra, discussed the application of ecology to the mixed hardwood forests of Northern New South Wales. He showed the importance of light in the regeneration of species such as Blackbutt, *Eucalyptus pilularis*, and the importance of the light factor in determining the outcome of competition between species. The importance of the development of lignotubers by some *Eucalyptus* species, in bringing about resistance to fires and subsequent regeneration following fires, was demonstrated. Light has been considered a major factor in determining the outcome of competition between species of the forest but latterly another school of thought has arisen which regards root competition as the decisive factor.

Dr. K. H. L. Key, Principal Research Officer, Division of Entomology, C.S.I.R.O., in speaking of the principles of animal ecology, outlined the fundamental differences between animals and plants and at the same time drew attention to the very important links between them. He revealed the very close dependence of plants and animals and said that the role of animals in determining the outcome of competition between plant species is not sufficiently appreciated. Synecology of animals cannot be carried out without studying plants but autecology can be studied in the laboratory where food and physical factors can be controlled. Population dynamics is

an important recent trend in a study of insect ecology.

Mr. T. A. Lang, Associate Commissioner of the Snowy Mountains Authority, will address the Branch on 4th November on the subject, "Development of the Water Resources of the Snowy Mountains".

New South Wales

The general meeting of the Branch held on 31st August, 1953, was devoted to a symposium on the subject of "Antibiotics in Agriculture". Mr. J. H. E. Mackay, of the C.S.I.R.O. Division of Plant Industry, spoke on "Antibiotics in Plant Pathology". In plants, as distinct from animals in which antibiotics merely have to prevent further growth of the organism, materials are needed which eliminate the pathogens from the host or produce a state of resistance in the host. Antibiotics are largely responsible for antagonism between organisms in the soil. In sterile soil, but not in non-sterile soil, the control of certain soil-borne diseases has been achieved on an experimental scale by the introduction of antibiotics. Streptomycin has given promising results with certain bacterial plant pathogens, when introduced into the host and actidione, which has a strong anti-fungal effect, is of some value. At present the use of antibiotics to control plant diseases is not very practicable, largely because of cost.

The inheritance of resistance to antibiotics was discussed by Dr. E. P. Baker, of the Faculty of Agriculture, University of Sydney. He reviewed the work in the medical field and indicated that bacteria, e.g. *Staphylococcus aureus*, acquire their resistance by mutations rather than by adaptation in the narrower sense. In any field it is clear that indiscriminate use of antibiotics should be avoided in order to discourage the development of resistant strains.

The subject of "Antibiotics in Animal Feeding" was dealt with in the form of a brief summary prepared by Dr. G. L. McClymont, who was unable to be present. It is now accepted that a number of antibiotics, when included in feed stuffs, increase the efficiency of food utilization and growth of pigs, calves and poultry. The effect is on "inapparent infections" and merely normalizes growth.

At the meeting of the branch on 29th September, 1953, members and visitors were addressed by Dr. C. J. Magee, Chief Biologist, N.S.W. Department of Agriculture, and Professor P. R. McMahon, School of Wool Technology, N.S.W. The subject of the joint address was "Some Views on the Future of Crops and Livestock in New Guinea". Dr. Magee stated that, being an old continental area largely composed of sedimentary rock, New Guinea was not generally highly fertile. Land suitable for agricultural development was limited but was greatly in excess of the requirements of the native population of 1-1½ million. Sweet potatoes and bananas are staple items of diet, but the coconut is the mainstay of New Guinea agriculture. A number of tropical crops can be grown but are not yet being produced on a commercial scale. In Dr.

Magee's opinion the greatest obstacle to agricultural development in New Guinea is the system of land tenure. Most of the land is entrusted to the natives and it is very difficult for prospective settlers to obtain land.

Professor McMahon recently visited the country to advise on the possibility of the use of sheep for wool and meat production. As well as some sheep there are a few small herds of cattle. Although pigs are highly valued, they are comparatively few in number and the establishment of other animals would be of great advantage, particularly in raising the protein level of the native diet. As one would expect, internal parasites present the biggest problem in introducing other livestock.

Queensland

In July the Branch held a meeting to which were invited representatives of the Government, the Public Service and commercial firms with agricultural and pastoral interests. The topic for discussion, "The Claims of Agricultural Research, Extension Work and Education for Greater Support", was introduced by a panel of four speakers:—Dr. W. A. T. Summerville, Director of the Division of Plant Industry, Department of Agriculture and Stock; Professor L. J. H. Teakle, Professor of Agriculture, University of Queensland; Mr. N. E. H. Caldwell, Manager of Taubmans Chemicals (Queensland) Pty. Ltd., and Mr. C. W. Winders, Officer in Charge of Information Services, Department of Agriculture and Stock.

The August meeting was postponed until 2nd September, when Mr. T. B. Paltridge, of the Plant and Soils Laboratory, C.S.I.R.O., Brisbane, addressed members on his recent trip through African pasture areas.

At a meeting held late in September research officers of the Department of Agriculture and Stock gave a series of talks on the work being conducted at the Maroochy Field Station near Nambour. Mr. B. L. Oxenham outlined investigations being made into virus diseases of citrus, Mr. T. Manefield described experiments on the control of red scale in citrus, Mr. G. W. Agnew indicated the problem of fruit types in papaws and described the papaw improvement programme, and Mr. F. Berril gave results of experiments with coloured plastic bunch covers for bananas.

Tasmania

With the departure for overseas of the Branch President, Professor H. N. Barber, Mr. D. S. Thompson has taken over the role of President of the Tasmanian Branch, and the Immediate Past President, Mr. T. D. Raphael, has been appointed Vice-President. Mr. E. F. Fricke was co-opted to fill the resultant vacancy on the branch committee.

On 17th July a joint meeting was held with the Tasmanian Branch of the Institute of Foresters of Australia. Speakers were Messrs. A. Crane, Commissioner for Forests, and F. W. Hicks, Superintendent of Extension and Technical Services, Tasmanian Dept. of Agriculture, and the subject discussed was "The Use of Marginal Lands with Particular Reference to the Brown-Chocolate Soils of the North West Coast".

The 60th general meeting of the Branch was held on 18th September. Messrs. G. C. Wade and L. W. Miller addressed members on "Recent Developments in Fungicides and Insecticides".

A business meeting was held on 26th October to give members an opportunity to discuss matters arising out of recent Council meetings. The main interest centred around the proposed "central secretariat".

Victoria

The Annual Dinner, held at the William Angliss Food Trades School on 22nd September, retained its reputation as the most popular Branch function of the year. The guest speaker was Sir F. Macfarlane Burnet, who discussed the future role of the myxomatosis virus in regard to Australia's rabbit population. Official guests included the President of the Institute, Dr. A. R. Callaghan, Sir John Medley and Cr. L. Allen, President, Victorian Chamber of Agriculture.

Dr. E. G. Bowen, O.B.E., Chief of the Division of Radiophysics, C.S.I.R.O., addressed a general meeting of the Branch on 25th September, on the subject, "Artificial rainmaking". He described the recent work of the C.S.I.R.O. in which cumulo-nimbus clouds had been stimulated to produce rain after seeding with pellets of dry ice dropped into the top of the cloud from an aircraft. With convective cumulus clouds, having a higher temperature, rain may be induced by spraying the base of the cloud with water. These phenomena were discussed and explained in relation to the known physical states and temperature relations within cloud formations.

Dr. Bowen also described overseas work on artificial rainmaking. One of the reasons for the failure of ground operated silver iodide smoke generators to induce rainfall in the U.S.A., was the fact that the silver iodide smoke did not reach the clouds they were intended to seed. This fact was established by controlled experiments in Australia.

Dr. Bowen stressed the points that rainfall could not be artificially induced unless suitable clouds were available, and that the process might be economically impracticable with existing methods.

An article by Dr. Bowen on this subject will be published in a later issue of this Journal.

Western Australia

Dr. T. C. Dunne addressed a general meeting of the Branch on Tuesday, 15th September, on the subject "Light Land Development at Esperance". Mr. F. L. Shier, the co-author of the paper, was to have spoken in conjunction with Dr. Dunne, but due to illness was unable to be present. In the introductory remarks the speaker described the Esperance plain which is an extensive area of coastal scrub with a good rainfall. Esperance is the nearest port, and although interest has been shown in the area in the past, settlement is sparse. In 1949, a commencement was made on the establishment of a research station 20 miles north of Esperance. The address covered mainly a review of the experimental work carried out by the Department of Agriculture at the Esperance Plain Research Station.

As is the custom the annual social re-union of this Branch was held during Show Week at the Shell Theatre on Monday, 5th October, and was attended by members and their wives and friends. This gathering gives an opportunity for country members attending the Royal Show to meet their fellow members. The function took the form of films and refreshments.

A fair proportion of our members availed themselves recently of the invitations of kindred societies to hear talks of particular interest to

agriculturalists. At a meeting on 1st September, organised by the W.A. Division of the Australian Society of Dairy Technology, an address was given by Mr. J. W. Lee, entitled "The Treatment of Skim Milk Powder for Use in Australian Bread".

More recently many of our members were able to attend a lecture by Professor F. Fenner on the subject of "Myxomatosis" through the courtesy of the Clinical Staff of the Royal Perth Hospital.

PERSONAL NOTES

Australian Capital Territory

Mr. C. S. Christian, Officer in Charge of the Land Research and Regional Survey Section, C.S.I.R.O., was Australian delegate at the recent meetings of the International Rice Commission at Bangkok.

Dr. E. Phillis, of the Land Research and Regional Survey Section, C.S.I.R.O., has recently left for Nauru to conduct a land potentiality survey for the Department of Territories.

New South Wales

Mr. H. Bartlett has retired from the position of Principal Agronomist (Extension) in the New South Wales Department of Agriculture after 40 years' service with the Department in the field of cereal crops. He has accepted a position as agricultural consultant to Pitt, Son and Badgery Ltd.

Miss Hilary Purchase has returned from a period of postgraduate study at Rothamstead Experiment Station. She has rejoined the staff of the School of Agriculture at the University of Sydney to work on root nodule bacteria.

Queensland

Mr. V. B. D. Skerman, Chief Lecturer in Bacteriology, University of Queensland, is now on study leave. After attending the International Congress on Microbiology in Rome in September, he will spend several months studying in Holland, Great Britain and the U.S.A.

Tasmania

Professor H. N. Barber, Botany Department, University of Tasmania, left in September for a twelve-months' visit to U.S.A. Professor Barber will be at the Californian Institute of Technology working on the genetic control of flowering in plants.

Mr. K. D. Nicholls, Division of Soils, C.S.I.R.O., will be leaving for overseas next March. He

will be on study leave for a period of eight months, and will be meeting fellow pedologists in England, Canada and U.S.A.

Victoria

Mr. J. W. Berryman, recently Agronomist in the Department of Agriculture at Launceston, has returned to his home State to join Power Farming Equipment Pty. Ltd. in Melbourne.

Mr. G. A. McKinley has resigned from the Soil Conservation Authority to take a position with Imperial Chemical Industries.

Western Australia

Mr. K. Fitzgerald, Agricultural Adviser in the North-West Branch of the Department of Agriculture, has resigned to take up a position with the Northern Territory Administration.

Mr. D. Fry, after two years' service in the Plant Research Branch of the Department of Agriculture, recently resigned to join his father in business.

Mr. D. Kirton, an Agricultural Adviser stationed at Geraldton, has resigned to take up a position with the Plant Industry Division, C.S.I.R.O., at the University of W.A.

Mr. F. Melville, of the Horticultural Branch of the Department of Agriculture, recently attended a meeting at Melbourne of the Co-ordination Council for the Investigation of Storage and Transport Problems of Fruit and Vegetables. He took the opportunity to visit the Horticultural Research Stations in Victoria, and toured the Murray Valley areas in Victoria and South Australia to obtain first-hand information on bud selection methods for citrus being used in those States.

Mr. T. Poutsma, formerly of the W.A. Region of C.S.I.R.O. Soils Division, has been transferred to headquarters at Waite Institute and will shortly be sent to Deniliquin Regional Laboratory.

NEWS ITEMS

Northern Tablelands Conference Tour

A group of about twenty-five research and extension officers from the C.S.I.R.O. and New

South Wales Department of Agriculture gathered at Armidale on October 19th for five days of concentrated observation and discussion of the

research, both veterinary and agrostological, being carried out in the New England district and on the Western slopes.

Visits were made to the C.S.I.R.O. "Chiswick" Field Station and to the New England Experiment Farm and Shannon Vale Nutrition Station of the New South Wales Department of Agriculture. Experimental plots were inspected at Uralla, Yarrawick and in the Inverell district. Several opportunities were given to members of the party to see the results of commercial broadacre pasture improvement and to discuss with landowners the practical difficulties of pasture establishment. One evening was given to discussing a report and recommendations on pasture research and extension work in the New England region submitted by the New England Regional Advisory Committee.

On the last afternoon of the tour a "plenary" session was held to discuss recommendations on such subjects as methods of pasture establishment, fertiliser treatments, recommended strains of grasses and clovers, rates of seeding, etc. Arrangements for the conference were made by the New South Wales Department of Agriculture and the C.S.I.R.O. Agricultural Research Liaison Section.

Back Numbers Wanted — Vol. 17, No. 1

Copies of Vol. 17, No. 1 (March, 1951) of the *Journal* are urgently required by the management to complete essential Institute records; this issue is also in demand by subscribers and libraries wishing to complete their sets.

Please send your copy to:—The Hon. Business Manager, J. A.I.A.S., C/- Librarian, Department of Agriculture, Treasury Place, Melbourne, C.2. and show sender's name and address clearly on the wrapper.

For each copy of this issue received the management will remit 5/- unless the sender specifically desires to have the copy accepted as a donation.

Conference Proceedings Available

The Proceedings of the Conference on Bacon and Ham Curing, which was referred to in the last issue of the *Journal*, have now been distributed to delegates.

The next meeting of the Australian Committee on Animal Production will review the Proceedings and consider recommendations made by the Conference.

Copies are available from the Agricultural Research Liaison Section, C.S.I.R.O., 314 Albert Street, East Melbourne, C.2.

Visitor from U.S.A.

During October Dr. Charles H. Kline, of the Climax Molybdenum Company, New York, visited the five eastern States and the A.C.T. to review Australian research, and its field applications, concerning molybdenum in agriculture. His company is sponsoring research on this subject in several U.S. universities, and his Australian visit was specifically to consult with acknowledged

world leaders in the fields of molybdenum in plant and animal nutrition.

He is now returning to the U.S.A. via New Zealand and Hawaii.

Professor F. M. Hull

Professor Frank M. Hull, Research Professor in Biology at the University of Mississippi, is spending four months in Australia with the Division of Entomology, C.S.I.R.O., Canberra.

Professor Hull is engaged on a study of world Diptera under a research grant from the National Science Foundation (U.S. Government). He spent the summer months of 1952 and 1953 at the British Museum, studying the world genera of the Asilidae, Bombyliidae and some of the Syrphidae. A Dipterist of many years' standing, he has a long list of publications to his credit in the U.S.

Professor Hull is accompanied by his wife and two sons.

International Rice Commission

Mr. C. S. Christian, Officer-in-Charge of the Land Research and Regional Survey Section of C.S.I.R.O., represented Australia as delegate at the recent meetings of the International Rice Commission at Bangkok. The third meeting of the Commission's "Working Party on Fertilizers" and the fourth meeting of the "Working Party on Rice Breeding" were held concurrently from the 21st to 27th September. Other countries represented were Burma, Cambodia, France, India, Indonesia, Italy, Japan, Pakistan, Philippines, Thailand, United Kingdom, U.S.A., and Vietnam.

While in Thailand, Mr. Christian was able to inspect some of the major rice growing areas, and on his return journey he visited some of the new rice development schemes in Malaya, some features of which may have some application to Northern Australia.

Scouts' Expedition to Tasmania

The C.S.I.R.O. is assisting the Boy Scouts Association in Victoria to organize an expedition to the West Coast of Tasmania during the Christmas vacation. The project originated, not from a primary need for exploration in Tasmania, but from the desire of the Scouting Movement in Victoria to stimulate an interest amongst Scouts and Rovers in the scientific appraisal of an environment.

The party comprising some 200 scouts will travel by air to Tasmania late in December. They will camp in Wynyard until the assembly is complete and then move by road to Corinna, which will be their base for a fortnight.

Mr. C. S. Christian will co-ordinate the work of the various scientific teams which will be led by officers of the University of Tasmania and the C.S.I.R.O. The leaders of the scientific groups will include specialists in soils, marine and freshwater biology, botany, wild life, geology and geomorphology. As with the full scale surveys of the Land Research and Regional Survey Section, use will be made of available aerial photographs of the area, from which the various

scientists will produce a plan for the sequence and location of the daily survey patrols. In addition to the co-ordinated traverses of the area planned for the general survey, selected groups will also undertake a number of patrols with individual objectives.

It is intended to write a report on the region at the completion of the undertaking, and it is anticipated that individual scientists may be enabled to prepare papers on specialist subjects as the result of their observations.

It was originally planned for the expedition to be made to Port Davey, on the inhospitable south-west coast of Tasmania. Transport difficulties, however, rendered this impossible this year, although it is anticipated that satisfactory arrangements will be made for a similar expedition to Port Davey in 1955.

Mr. E. Y. Hosaka

Mr. E. Y. Hosaka, Specialist in Range Management, College of Agriculture, University of Hawaii, has just arrived in Australia for a period of about six months. Mr. Hosaka's visit is sponsored by C.S.I.R.O., and the Commonwealth Bank. During his period in Australia, Mr. Hosaka will devote special attention to the problems of pasture development in the tropical and subtropical parts of the continent. He will advise on the further trial and development of new pasture legumes for these regions—a field of work in which he has had lengthy experience in Hawaii.

Conference Proceedings — Isotopes

A publication of some interest has recently been received in C.S.I.R.O. library. This is the Proceedings of a Conference held in June, 1952, in Manhattan, Kansas, on the use of isotopes in plant and animal research. The Conference was sponsored by the Kansas State College of Agriculture and Applied Science, by the Argonne National Laboratory and by the United States Atomic Energy Commission, Isotope Division.

The first paper to be presented was one by Paul C. Aebersold, Director of the Isotope Division of the Atomic Energy Commission, giving a survey of the present uses of isotopes in agriculture.

This general survey on the present uses of isotopes is followed by 18 specialist papers giving in some detail experimental projects carried out by research workers of the Atomic Energy Commission, the U.S. Department of Agriculture, and various of the State Agricultural Experiment Stations.

The publication which appeared in April, 1953, has been issued by the Atomic Energy Commission, Technical Information Division, as Document No. 5098. It is also numbered Report No. 4 of the Kansas State College Agricultural Experiment Station and it is available for purchase from the United States Superintendent of Documents at a cost of \$1.25.

Eighth International Congress of Botany

The VIIIth International Congress of Botany will be held in Paris from 2nd to 14th July, 1954, coinciding with the centenary of the Botanical Society of France. The last Congress was held in Stockholm in 1950.

Attendance and submission of original communications have been invited. Twenty-seven subject-matter sections have been established, including various Commissions of the International Union of Biological Sciences. Numerous colloquia are being organised and other section sessions will be devoted to sundry communications. Arrangements are being made for a number of functions and excursions in association with the Congress.

Information and programmes are obtainable from the "Secretariat-General", VIIIe Congrès de Botanique, C.N.A.M., 292 rue Saint-Martin, Paris, IIIe.

BOOK REVIEW

FIELD EXPERIMENTATION WITH FRUIT TREES AND OTHER PERENNIAL PLANTS

By S. C. PEARCE

(Commonwealth Bureau of Horticulture and Plantation Crops Technical Communication No. 23, 1953, X + 131 pp. Obtainable from the C.A.B. Liaison Officer at 314 Albert Street, East Melbourne, C2. Price 12/6).

This is a very welcome addition to the literature dealing with design and analysis of experiments in specialised fields.

The publication covers the usual range of simpler designs, methods of analysis, statistical measures of significance, adjustments for missing plots, sampling, etc., although more attention has been given to modified forms of latin squares than is usual. What is of particular interest and importance to the reader is the thorough-

ness with which the author deals with the merits of alternative procedures and designs in terms of his experience at East Malling with variability in fruit crops and problems of management.

One can recommend the publication to all who work with perennial crops. They will find in it a mine of commonsense comment on the inevitable problems which arise in this field.

LETTER TO THE EDITOR

Sir,

In the September issue of this Journal, Mr. Schapper challenged some of the propositions contained in my article published in the previous number.

He has asserted that my "typical pattern" of distribution of the benefits of technological progress in agriculture—where most of the benefits are passed to the economy at large rather than retained by farmers—has been the exception rather than the rule in Australia in the immediate past. His principal argument is that administrative pricing based on production costs has enabled farmers to retain these benefits. But surely this institutional factor is not anywhere near so important as Mr. Schapper believes.

First, the commodities covered by such pricing procedures do not represent a significant proportion of aggregate agricultural production. Second, to have the effect which Mr. Schapper attributes to them, the pricing techniques employed have to be of a particular form. Price determinations must be based solely on cost movements and these must be ascertained by index number procedures. None of these conditions holds universally. Provision is generally made for periodic surveys to amend the physical assumptions on which the costing is based. Moreover, we seem to be rapidly passing out of the phase where price was based directly on cost determinations without reference to demand considerations. In short, Mr. Schapper's theory may be right under certain very restricted conditions, but its practical significance is negligible.

At the same time, I believe that Australian farmers are enabled to retain more of the benefits of technological progress than farmers in a closed non-progressive economy, for the reasons stated in my article, viz., the greater elasticity of export demand and increasing domestic consumption. On the other hand, there are powerful institutions in the Australian economy, particularly the arbitration system, which tend to reinforce the tendency for the non-agricultural community to benefit quickly from increases in agricultural productivity.

My remarks about the economic effects of agricultural progress were not intended as a complete analysis of this question. My purpose in presenting what I did was simply to point out the unwisdom of basing extension programmes on the traditional belief that the benefits of technological progress accrue primarily to the farmer. I did stress the benefits to the nation as a whole which flow from increased agricultural productivity. Once stated clearly, I see no reason to elaborate this point in a discussion on factors affecting the rate of adoption of new techniques. Few farmers are likely to adopt new practices primarily to promote the general welfare.

Mr. Schapper has inferred that I drew certain conclusions from the Iowa study on hybrid maize which a careful reading of my article will show I did not draw. I cited this study merely as an example, in the absence of Australian data. My conclusions on the relative influence of extension services on farmers' adoption of new practices were certainly not prompted solely by that study, nor were my arguments for a more comprehensive approach to extension based thereon. I indicated that the results of such surveys need to be interpreted with caution—that much depends on the type of technique in question. It is clear, for instance, that where a particular practice cannot easily be commercialised, or where considerable capital investment is involved, the role of business firms may be insignificant. Mr. Schapper himself oversimplifies the issues. I doubt very much whether any "Department of Agriculture would score full marks" with respect to the ultimate adoption of any particular practice. The influence of neighbourhood and family example is too strong.

Mr. Schapper appears to attach certain theoretical overtones to the word "expectations", which I used in its ordinary English meaning. I would agree that only a minority of farmers have expectations which are measurable in any strict probability sense. However, farmers do have a set of psychological attitudes about the future and these are affected by government policy. In an article published in the same issue of the Journal, Mr. Schapper himself refers to farmers as having a "next slump complex" and suggests action to help eliminate it. Apparently the difference between Mr. Schapper and myself on this point is neither real nor important.

Assertions by Mr. Schapper and some private correspondents that the emphasis in my article was misplaced and unhelpful at a period when extension budgets are on the increase, suggests a most disturbing "guilt complex" on the part of professional agriculturalists as regards these appropriations. I believe that it is just at such a time that members of the agricultural profession should re-examine their beliefs about extension procedures, with a view to ensuring that the most effective service is given, and that the public gets maximum returns for its investment. The general public should be encouraged in the same direction. That extension is a sound form of national investment there should not be any doubt.

Yours, etc.,

KEITH O. CAMPBELL,

Reader in Agricultural Economics,
University of Sydney.
23rd October, 1953.



THE YIELDS OF A CROP

By W. LAWRENCE BALLS, F.R.S.

(*E. and F. N. Spon, London, 1953, pp. xv + 144, 21s. English; review copy supplied by Melbourne University Press.*)

The crop referred to is the cotton crop as grown in Egypt on the alluvial soils of the Nile and its delta. The conditions of these localities are such as to afford the scientific observer an almost unrivalled opportunity to study the growth of the cotton plant from an autecological point of view. This work has been going on for nearly half a century, and was originally reported on in the classical papers by the author in the Philosophical Transactions of the Royal Society of London (B series) 1915. Special aspects of the subject have been referred to in numerous other publications. This present book summarises this accumulated knowledge, and although it refers to a special crop which is only of interest to a limited range of readers, yet its approach to the study of the problem might well be taken as a standard by all those who seek to analyse crop growth or the yields of any crop plant.

Thanks to this special knowledge the author has been able to correlate new developments in regard to the cotton plant in recent years with changes in the irrigation system, and consequent alterations in the water table. This investigation should be of great interest to all those who deal with the hydrology of the soils in and near river valleys.

The analysis of the yields over a period of half a century is dealt with in detail. The effects of factors of recent importance, such as the effects of insects, pests, the application of fertilizers and the increases due to the work of the plant breeders are assessed quantitatively by ingenious methods, so that finally the author is able to show a progressive decline in the capacity of the delta to grow cotton.

The final chapter discusses the possibilities of the future; the economic advantage to be derived from an expensive remodelling of the irrigation plan; and the almost inevitable conclusion that nothing will be done.

The book is a condensation, and as a result the author has not made it particularly easy

for the reader who happens to be unacquainted with the original papers in the Philosophical Transactions, or in the earlier volume "The Cotton Plant in Egypt", but it would be well worth the while of most plant investigators in Australia to study the whole matter with care.

S. M. WADHAM.

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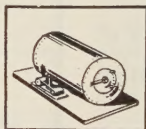
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